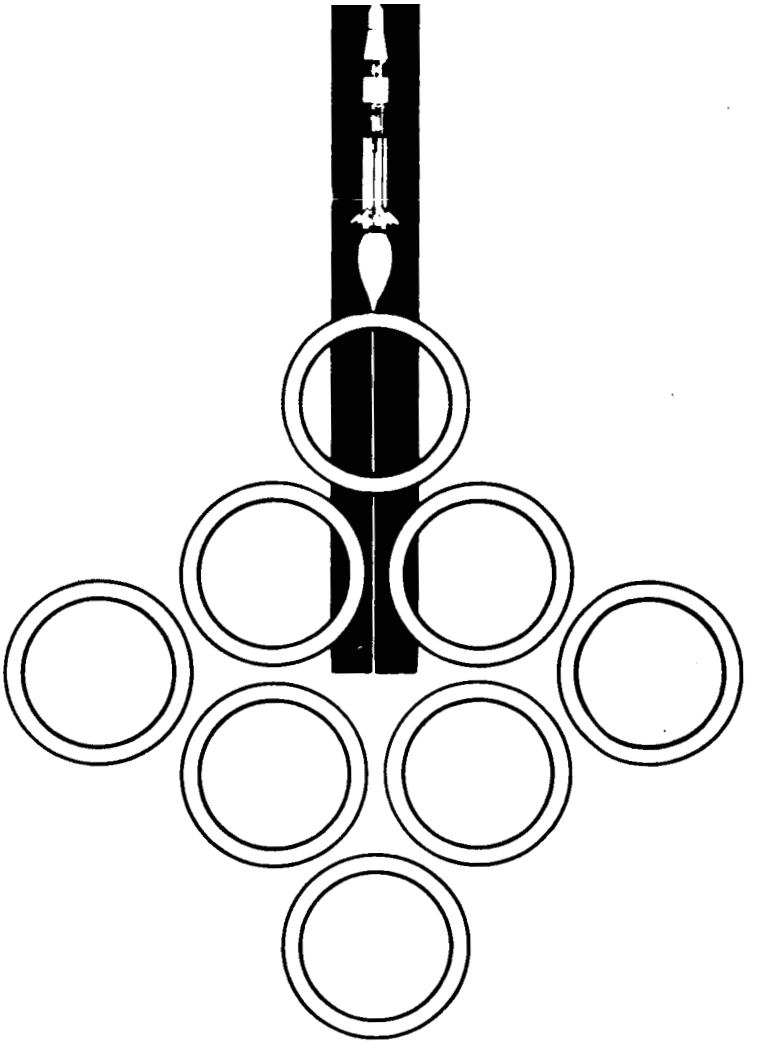

ENGINEERING DEPARTMENT

TECHNICAL REPORT

TR-RE-CCSD-FO-1006-3

February 14, 1967

SATURN IB PROGRAM

TEST REPORT
FOR

PNEUMATIC FILTER, 3/8-INCH

Permanent Filter Corporation Part Number 10813

NASA Drawing Number 10437650

SPACE DIVISION CHRYSLER CORPORATION

TR-RE-CCSD-FO-1006-3

TEST REPORT

FOR

PNEUMATIC FILTER, 3/8-INCH

Permanent Filter Corporation Part Number 10813

NASA Drawing Number 10437650

February 14, 1967

CHRYSLER CORPORATION SPACE DIVISION - NEW ORLEANS, LOUISIANA

FOREWORD

The tests reported herein were conducted for the John F. Kennedy Space Center by Chrysler Corporation Space Division (CCSD) New Orleans, Louisiana. This document was prepared by CCSD under contract NAS8-4016, Part VII, CWO 271620.

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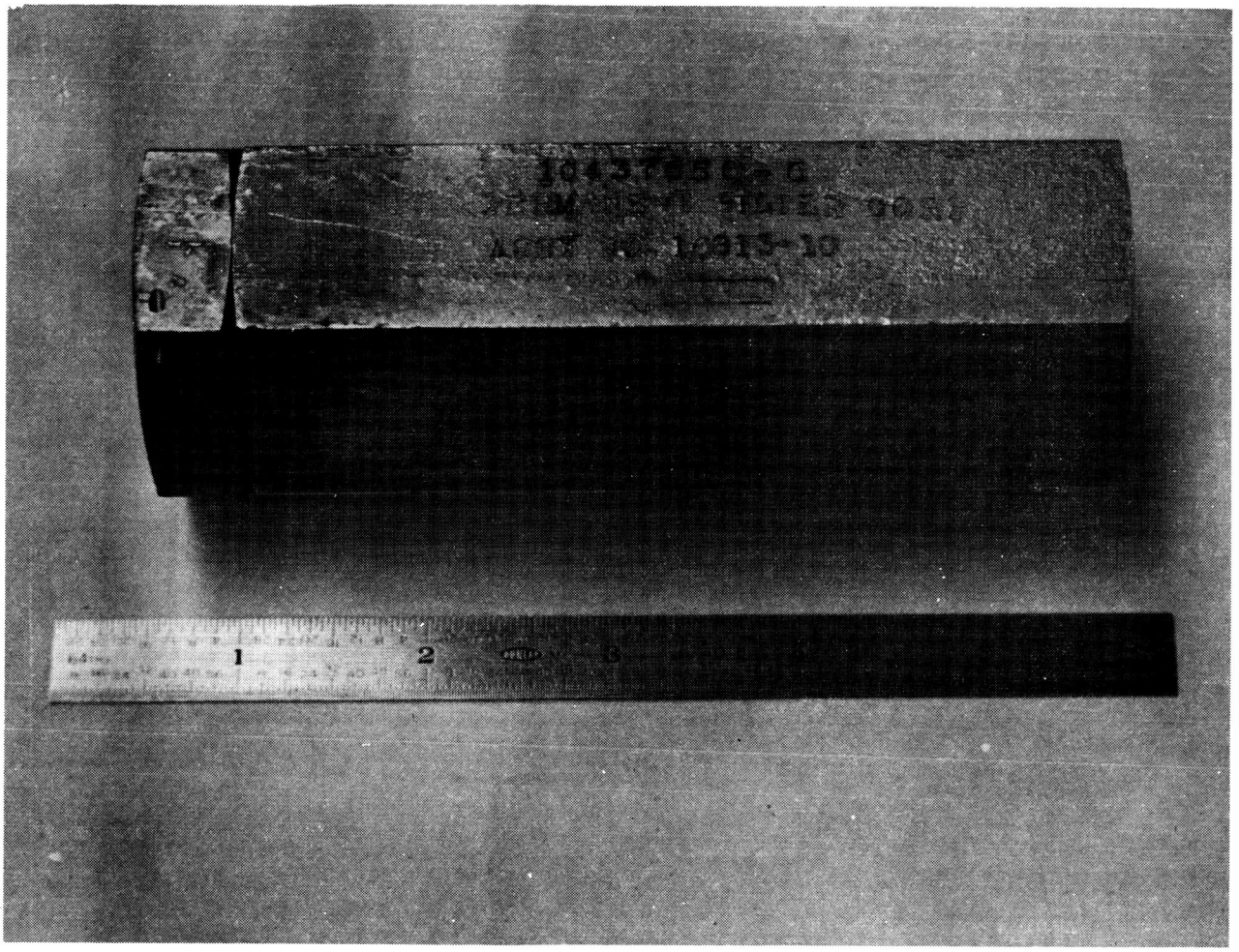


Pneumatic Filter, 3/8-Inch, 10437650

CHECK SHEET

FOR

PNEUMATIC FILTER. 3/8-INCH

MANUFACTURER: Permanent Filter Corporation
MANUFACTURER'S PART NUMBER: 10813
NASA PART NUMBER: 10437650
TESTING AGENCY: Chrysler Corporation Space Division, New Orleans, Louisiana
AUTHORIZING AGENCY: NASA KSC

I. FUNCTIONAL REQUIREMENTS

A.	OPERATING MEDIUM:	Gaseous nitrogen. air. and/or gaseous oxygen
B.	OPERATING PRESSURE:	0 to 5000 psig
C.	RATED OPERATING PRESSURE:	0 to 6000 psig
D.	LEAKAGE:	None allowed
E.	FLOW:	10 cfm air or gaseous nitrogen at 6000 psig
F.	PRESSURE DROP:	Approximately 2 psi at rated flow

II. CONSTRUCTION

A.	BODY MATERIAL:	Stainless steel
B.	TYPE CONNECTION:	AND10050-6
C.	TYPE OF ELEMENT:	Sintered bronze
D.	MICRON RATING:	10 nominal, 30 absolute

III. ENVIRONMENTAL CHARACTERISTICS - MANUFACTURER'S SPECIFICATIONS

A.	OPERATING TEMPERATURE RANGE:	0 to 160°F
B.	PROOF PRESSURE:	9000 psig
C.	BURST PRESSURE:	24,000 psig

IV. SPECIAL REQUIREMENTS

A.	CLEANING:	Permanent Filter Corporation Cleaning Process PSF-551 or Customer Approved Equal Flurolube. Kel-F-10 or grease per MIL-L-4343.
B.	LUBRICANTS:	

V. LOCATION AND USE: This filter is located on the Apollo access arm and is used to filter particles out of the pneumatic accumulator supply.

Test Summary

Pneumatic Filter

10437650

Environment	Units	Operational Boundary	Test Objective	Test Results	Remarks
Receiving Inspection	3	Conform to applicable drawings	Check for conformance with applicable drawings	Satisfactory	Test Completed
Proof Pressure	3	9000 psig for 5 min.	Check for leakage	Satisfactory	No leakage
Bubble Point (Element Only)	3	Pressurize while Submerged in Solox 190	Determine micron rating	Unsatisfactory	Computed Micron rating approximately twice manufacturers rating
Low Temperature	2	Environmental temperature 5°F Pressurize to 6000 psig for 1 hr	Check for leakage	Satisfactory	No leakage
High Temperature	2	Environmental temperature 160°F pressurize to 6000 psig for 72 hrs.	Check for leakage	Satisfactory	No leakage
Flow	2	2-psi pressure drop 10 cfm 6000 psig	Determine flow characteristics	Unsatisfactory	2-psi pressure drop is unrealistic for this flow and pressure
Surge	2	0 to 6000 psig in 100 milliseconds 1000 cycles	Determine if specimen operation is impaired by surge	Satisfactory	Test Completed without discrepancies
Vibration	2	Sinusoidal Sweep: 10 to 44 cps at 0.1 in. DA 44 to 2000 cps at 10g peak random excitation: 10 to 100 cps at +6 db/octave 100 to 1000 cps at 0.01 g^2/cps 1000 to 2000 cps at -6 db/octave. Specimen pressurized to 6000 psig	Check for leakage and structural degradation	Satisfactory	No leakage
Salt Fog	2	5% by weight salt solution at 95°F for 240 hr	Check for deterioration and degradation	Satisfactory	No degradation or deterioration
Dirt Holding and Collapse Pressure	2	Add AC test Dust to flow at 10 cfm until pressure stabilizes or element collapses	Add test dust in 0.50- gram slurries	Satisfactory	Complete element collapse
Final Inspection	3	Degradation, distortion or deterioration due to testing	Check for effects of testing	Satisfactory	Test completed
Burst	3	24,000 psig for 5 minutes	Determine structural integrity	Marginal	Two of three specimens failed at 24,000 psig

SECTION I

INTRODUCTION

1.1 SCOPE

This report presents the results of tests that were performed to determine if Pneumatic Filter 10437650 meets the operational requirements for the John F. Kennedy Space Center Launch Complexes 34 and 37. A summary of the test results is presented on page ix.

1.2 ITEM DESCRIPTION

1.2.1 Three specimen of pneumatic filter 10437650 were tested. The filter is a 3/8-inch pneumatic filter which is used on the Apollo access arm to filter particles out of the pneumatic accumulator supply.

1.2.2 Pneumatic filter 10437650 is manufactured by Permanent Filter Corporation as vendor part number 10813. The filter is a 3/8-inch in-line type filter with a sintered bronze element which is 2-1/2 inches long and 7/8 inch in diameter. The element is housed in a 1-3/4-inch hexagonal stainless steel body 5 inches long with female ports. The filter element is attached to the removable end cap. An O-ring is used to seal the end cap to the filter housing.

1.3 APPLICABLE DOCUMENTS

The following documents contain the test requirements for Pneumatic Filter 10437650.

a. KSC-STD-164(D), dated September 17, 1964, Standard Environmental Test Methods for Ground Support Equipment Installations at Cape Kennedy.

b. Component Specification 10437650

c. Test Plan CCSD-FO-1006-1R

d. Technical Procedure CCSD-FO-1006-2R

SECTION II

RECEIVING INSPECTION

2.1 TEST REQUIREMENTS

2.1.1 Each test specimen shall be visually and dimensionally inspected to determine its conformance with the applicable specifications prior to testing.

2.1.2 Disassembly of the test specimens is permitted for the purpose of performing a receiving inspection on the filter element.

2.2 TEST PROCEDURE

A visual and dimensional inspection was performed to determine compliance with NASA drawing 10437650 and the applicable vendor drawing. At the same time each test specimen was also inspected for poor workmanship and manufacturing defects.

2.3 TEST RESULTS

Each specimen complied with NASA drawing 10437650. No evidence of poor workmanship or manufacturing defects was observed.

2.4 TEST DATA

The data presented in table 2-1 were recorded during the inspection.

Table 2-1. Specimen Size and Identification

Item	Specimen 1	Specimen 2	Specimen 3	Requirement
Length (inch.)	5.00	5.00	5.00	5.00
Width (across flats) (in.)	1.75	1.75	1.75	1.75
NASA Part No.	10437650	Same	Same	None
Vendor Part No.	10813-10	Same	Same	None
Serial Number	None	None	None	None

SECTION III

PROOF PRESSURE TEST

3.1 TEST REQUIREMENTS

Each test specimen shall be subjected to a proof pressure of 9000 psig for 5 minutes. Gaseous nitrogen (GN_2) shall be used as the test medium.

3.2 TEST PRODCEDURE

3.2.1 The outlet port of each specimen was capped and the inlet port connected to a high pressure GN_2 source as shown in figures 3-1 and 3-2 using the equipment listed in table 3-1.

3.2.2 The filter assembly was immersed in a tank of deionized water.

3.2.3 Hand valves 8 and 10 were closed.

3.2.4 Pressure regulator 5 was adjusted for zero outlet pressure.

3.2.5 Hand valves 4 and 8 were opened.

3.2.6 The filter housing was pressurized to 9000 psig for 5 minutes using pressure regulator 5. The specimen was observed during this period for possible leakage.

3.2.7 Hand valve 8 was closed and the specimen pressure vented through hand valve 10.

3.2.8 The filter housing was removed and examined for damage or distortion.

3.3 TEST RESULTS

No leakage was detected from any specimen.

3.4 TEST DATA

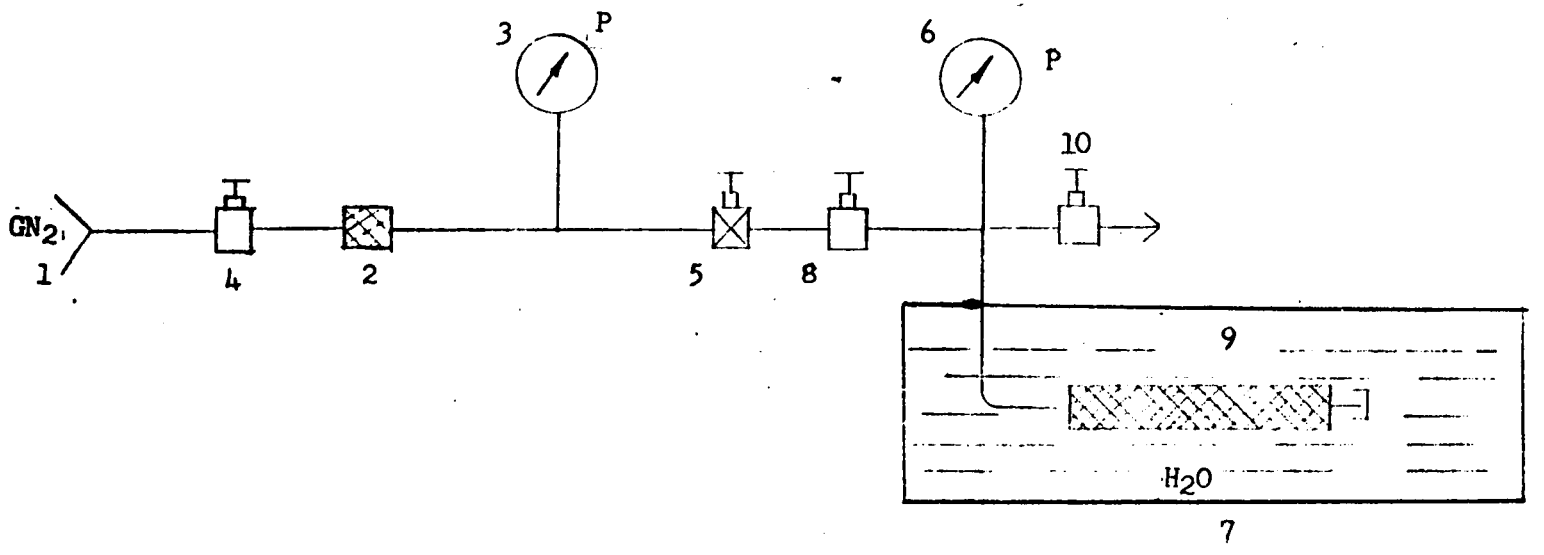
The data presented in table 3-2 were recorded during the proof pressure test.

Table 3-1. Proof Pressure Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Source	CCSD	NA	NA	9500-psig
2	Filter	Microporous	4813F-20M	NA	2-micron absolute
3	Pressure Gage	Ashcroft	NA	NASA 95-1508-B	0-to 10,000-psig, ±2% FS accuracy Dal date 4/7/67
4	Hand Valve	Aminco	13126	NA	1/2-inch
5	Pressure Regulator	Tescom	26-1021-20	NA	0-to 10,000-psig outlet
6	Pressure Gage	Neise	H-34955	014231	0-to 10,000-psig, ±0.25% FS accuracy Cal date 11/26/66
7	Water Tank	CCSD	NA	NA	Deionized water
8	Hand Valve	Aminco	50011-A	NA	1/4-inch
9	Test Specimen	Permanent Filter Corp.	10813	NA	Pneumatic filter, 3/8-inch
10	Hand Valve	Aminco	5011-A	NA	1/4-inch

Table 3-2. Proof Pressure Test Results

Item	Specimen 1	Specimen 2	Specimen 3
Pressure	9000 psig	9000 psig	9000 psig
Leakage	None	None	None
Distortion	None	None	None



Note: All lines 1/4 inch. Refer to table 3-1 for item identification.

Figure 3-1. Proof Pressure Test Schematic

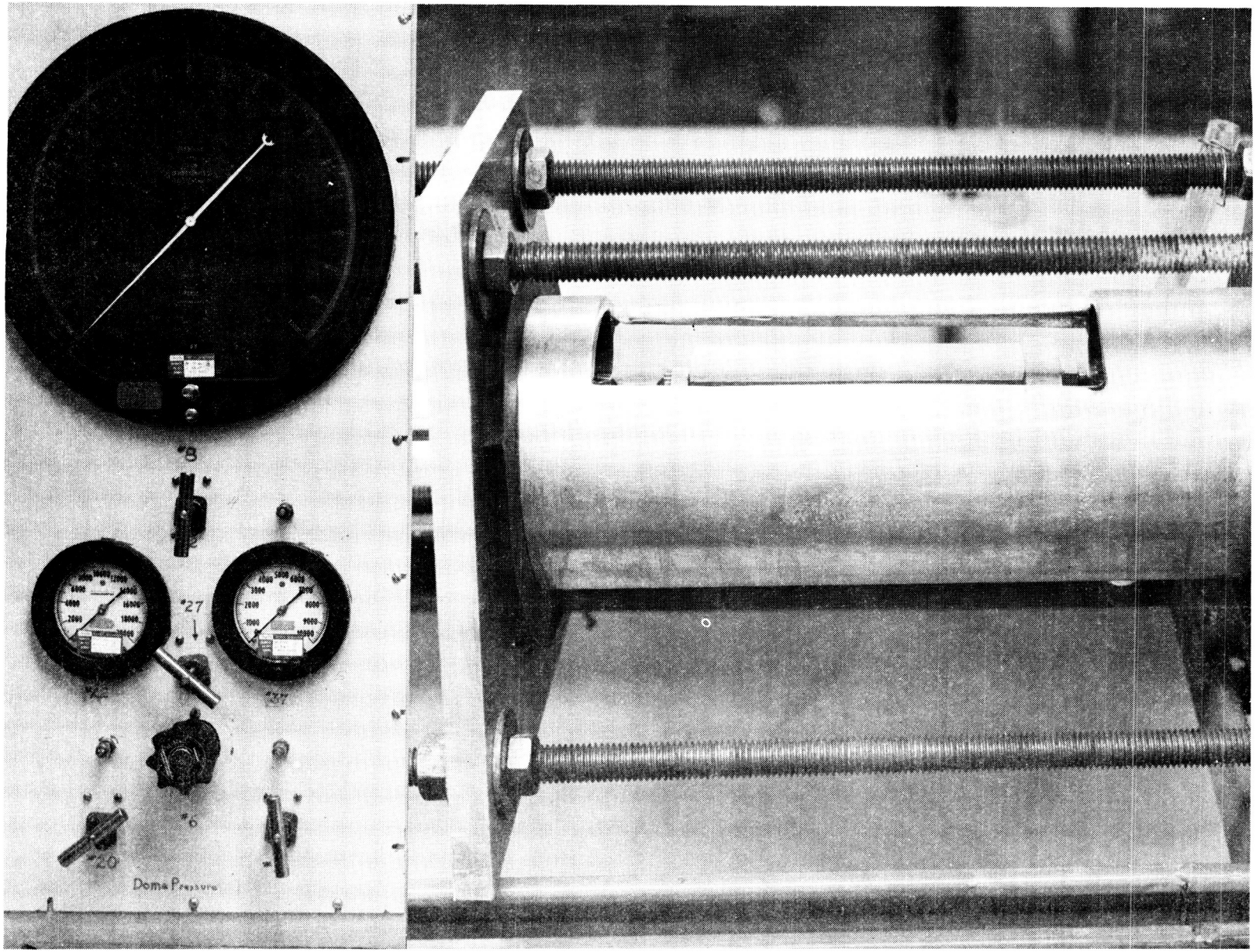


Figure 3-2. Proof Pressure Test Setup

SECTION IV

BUBBLE POINT TEST

4.1 TEST REQUIREMENTS

A bubble point test shall be performed on each specimen to determine the micron rating of each filter element.

4.2 TEST PROCEDURE

4.2.1 Each filter element was removed from its housing and installed in a test setup as shown in figures 4-1, 4-2, and 4-3 utilizing the equipment listed in table 4-1.

4.2.2 The filter element was allowed to soak for 1 minute in the solox 190 before proceeding with the test. The fluid level was maintained between 0.4 and 0.6 inch above the level of the element during the test.

4.2.3 With all hand valves closed pressure regulator 2 was adjusted for zero outlet pressure.

4.2.4 Hand valve 7 was opened.

4.2.5 Regulator 2 was adjusted for 100-psi outlet pressure. Hand valve 4 was slowly opened until the first bubble appeared. The element was carefully rotated while increasing the pressure to assure only one breakthrough point at the lowest possible pressure. The pressure at the breakthrough point was recorded from manometer 8.

4.2.6 Using a constant of 209, the micron rating of the filter element was determined from the following equation.

$$\text{Micron Rating } (\mu) = \frac{209}{\text{Bubble Point}}$$

where: bubble point = pressure (inches of water)

4.2.7 Using hand valve 4 the pressure was slowly increased until the gas bubbled furiously from the entire length and circumference of the element. The element was constantly rotated and allowed to bubble for 1 minute.

4.2.8 Hand valve 4 was closed and the element allowed to bubble until the last bubble appeared. The pressure on manometer 8 at this point was recorded.

4.2.9 The procedure described in 4.2.6 was repeated using a constant of 188.

4.2.10 The test was repeated three times and average data were used to determine the micron rating.

4.2.11 Regulator 2 was reduced to zero outlet pressure.

4.2.12 All test data were recorded.

4.3 TEST RESULTS

The numerical results obtained during the initial bubble point test indicate a micron rating higher than that allowed.

4.4 TEST DATA

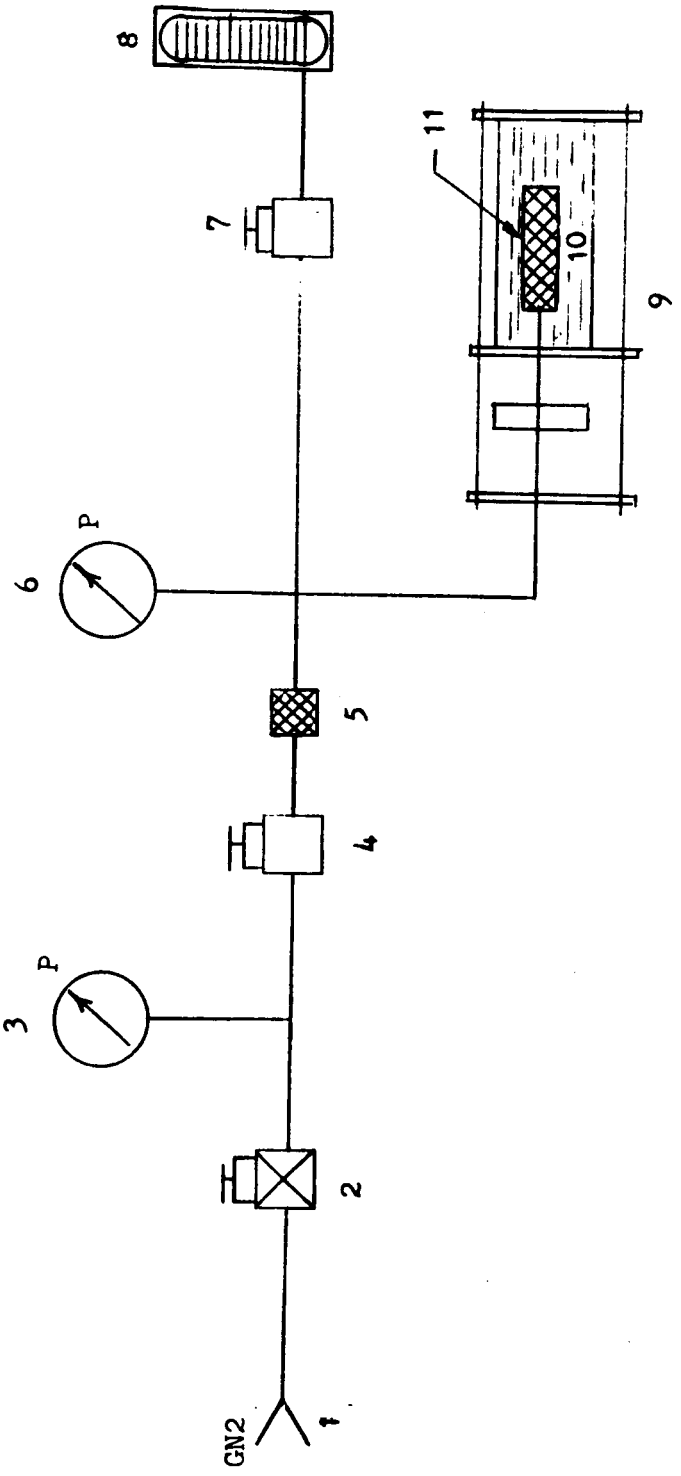
The data presented in table 4-2 were recorded during the initial bubble point test.

Table 4-1. Bubble Point Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Source	Laboratory Supply	NA	NA	2000-psig bottle
2	Pressure Regulator	Linde Co.	R-89	NA	0-to 2000-psig outlet
3	Pressure Gage	Linde Co.	BU-2581-AP-26617-1	NA	0-to 3000-psig
4	Micrometer Hand Valve	Whitney	22 RF4	NA	1/4-inch
5	Filter	Nuclear Products Co.	SS-4FR-7	NA	2-Micron absolute
6	Pressure Gage	Heise	H34949	NA	0-to 1000-psig ±2% FS accuracy Cal date 1/3/67
7	Hand Valve	Robbins Aviation	SSKG 250 4T	NA	1/4-in
8	U Tube Manometer	Miriam Instrument Co.	20 DA 40	Z37322	H_2O, Cal date 12/23/66
9	Tank Bubble Point Test	CCSD	NA	NA	
10	Solox 190		NA	NA	
11	Specimen	Permanent Filter Corporation	10813	NA	Pneumatic Filter, 3/8-inch

Table 4-2. Initial Bubble Point Test Data

Item	Micron Rating (Microns)	
	209 Constant	188 Constant
Specimen 1	36.4	42.7
Specimen 2	36.7	44.2
Specimen 3	35.4	43.7



Note: All line 1/4 inch. Refer to table 4-1 for item identification.

Figure 4-1. Bubble Point Test Schematic

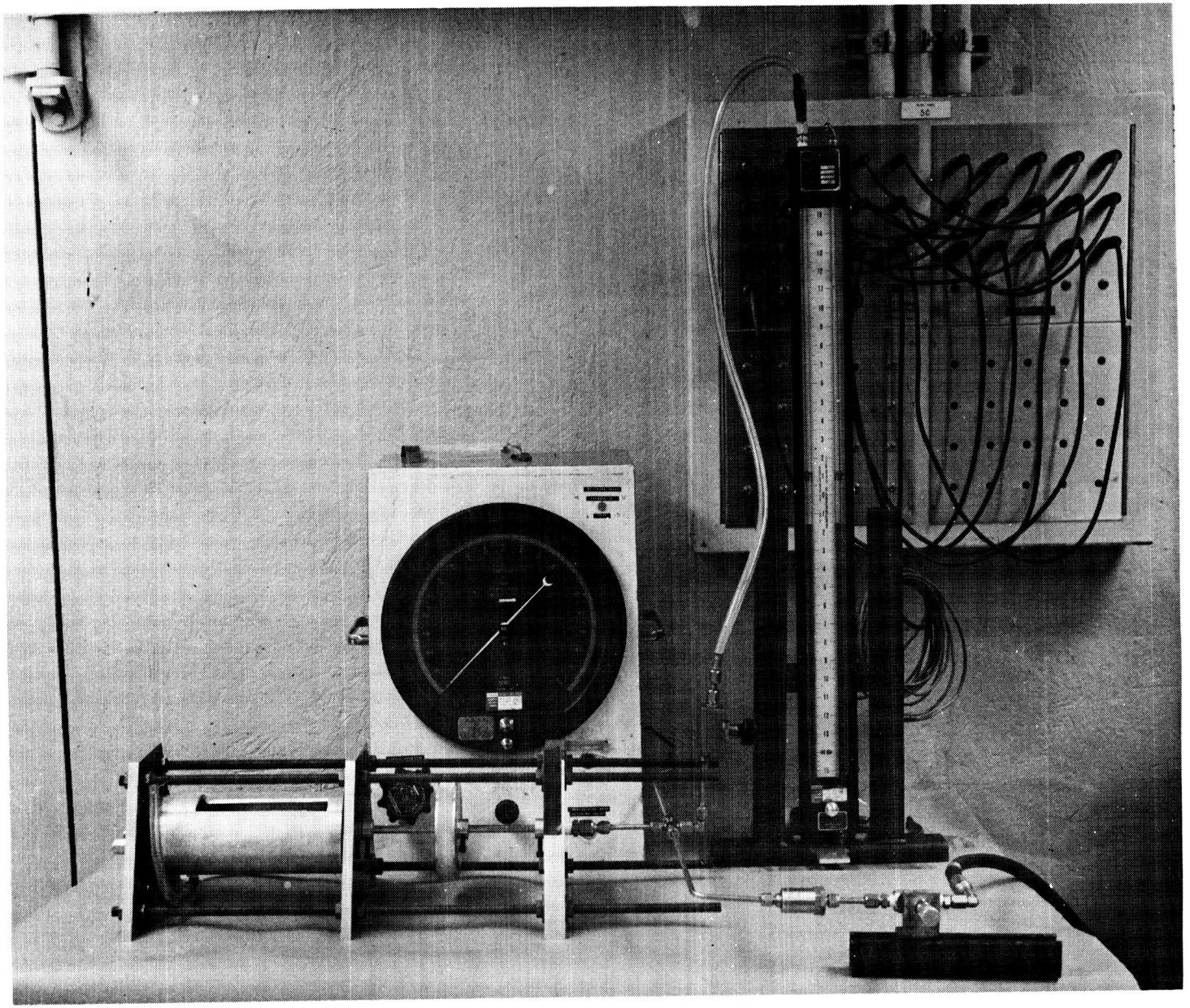


Figure 4-2. Bubble Point Test Setup

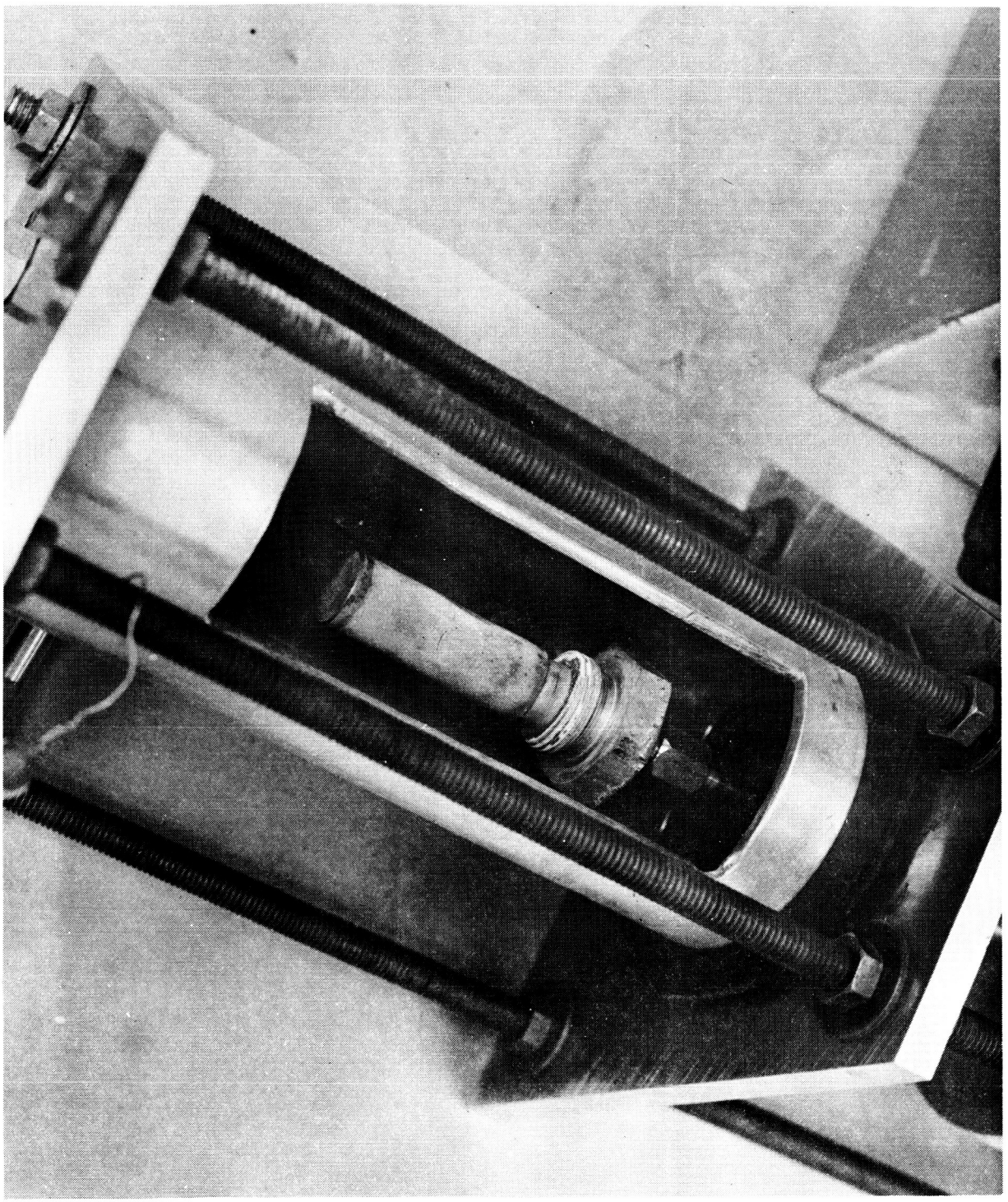


Figure 4-3. Bubble Point Test Setup Showing Location of Test Filter Element

SECTION V

LOW TEMPERATURE TEST

5.1 TEST REQUIREMENTS

5.1.1 A low temperature test shall be performed on the test specimens to determine whether the environment cause degradation or deformation, to establish the suitability of the gasket materials, and to determine the thermal effects upon the bubble point.

5.1.2 The rated low temperature is 5(+0, -4)°F.

5.1.3 A bubble point test shall be performed before (if 72 hours or more has elapsed since the previous bubble point test), during, and within 1 hour following the test.

5.2 TEST PROCEDURE

5.2.1 Each test specimen was placed in a low temperature chamber as shown in figures 5-1 and 5-2 utilizing the equipment listed in table 5-1.

5.2.2 The temperature within the chamber was controlled at 5(+0, -4)°F while a relative humidity of 60 - 90 per cent was maintained.

5.2.3 Pressure regulator 5 was adjusted for zero outlet pressure.

5.2.4 With hand valve 2 open, each specimen was pressurized to 6000 psig for 1 hour using pressure regulator 5. Specimen leakage was continuously monitored during the interval.

5.2.5 Hand valve 2 was closed and the pressure reduced to zero using regulator 5.

5.2.6 The specimen was removed from the chamber and the filter element separated from the body.

5.2.7 The element was then placed in the bubble point test setup.

5.2.8 The temperature of the filter element and the solox 190 was decreased to 5(+0, -4)°F. A bubble point test was performed at this temperature.

5.2.9 The specimen and test medium were allowed to return to ambient conditions and a bubble point test was conducted.

5.2.10 All test data were recorded.

5.3 TEST RESULTS

5.3.1 No leakage was observed from either specimen during the low temperature test.

5.3.2 Bubble point test results indicated a lower micron rating at low temperature.

5.4 TEST DATA

Leakage and bubble point data are presented in tables 5-2 and 5-3.

Table 5-1. Low Temperature Test Equipment List

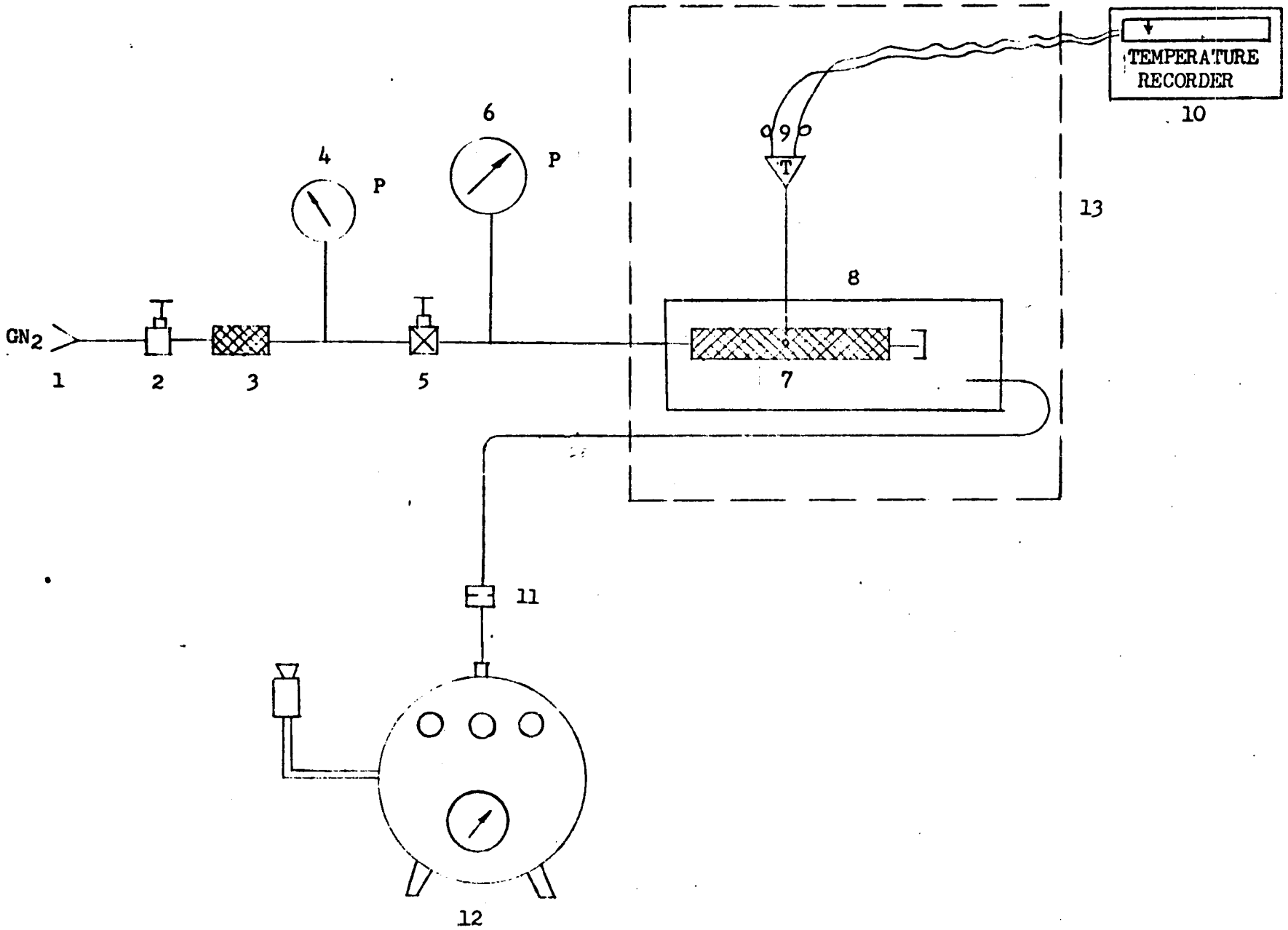
Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Source Pressure	Laboratory Supply	NA	NA	9500-psig
2	Hand Valve	Aminco	13126	NA	10,000-psi
3	Filter	Fluid Dynamics	FL-OZ-888	4066	2-micron absolute
4	Pressure Gage	Ashcroft	NA	NASA-95-1508-B	0-to 10,000-psig, ±2% FS accuracy Cal date 4/7/67
5	Pressure Regulator	Tescom	26-1021-20	NA	10,000-psig outlet
6	Pressure Gage	Heise	H-34955	014231	0-to 10,000-psig, ±2% FS accuracy Cal date 11/26/67
7	Test Specimen	Permanent Filter Corporation	10813	NA	Pneumatic filter, 3/8 inch
8	Test Enclosure	CCSD	NA	NA	
9	Temperature Probe		NA	NA	Copper constantan
10	Temperature Recorder	Honeywell	NA	S4704-211002	-100 to 500°F (±1%) Cal date 12/20/66
11	Orifice	CCSD	NA	NA	0.025-inch diameter
12	Wet Test Meter	American Meter Co.	AL-18	15366	ft^3 0.1 per revolution Cal date 1/10/67
13	Environmental Temperature Chamber	CCSD	NA	NA	-5 to +165°F at 15 to 90% RH

Table 5-2. Leakage During Low Temperature Test

Test Specimen	Leakage (scim)
1	None
2	None

Table 5-3. Bubble Point Test Results (Low Temperature Test)

Test Specimen	Micron Rating (Microns)					
	Before Low Temperature		@ Low Temperature		After Low Temperature	
	209 Constant	188 Constant	209 Constant	188 Constant	209 Constant	188 Constant
1	36.4	42.7	32.7	38.4	35.4	38.3
2	36.7	44.2	29.8	36.8	33.7	36.9



Note: All lines 3/8 inch. Refer to table 5-1 for item identification.

Figure 5-1. Low and High Temperature Test Schematic

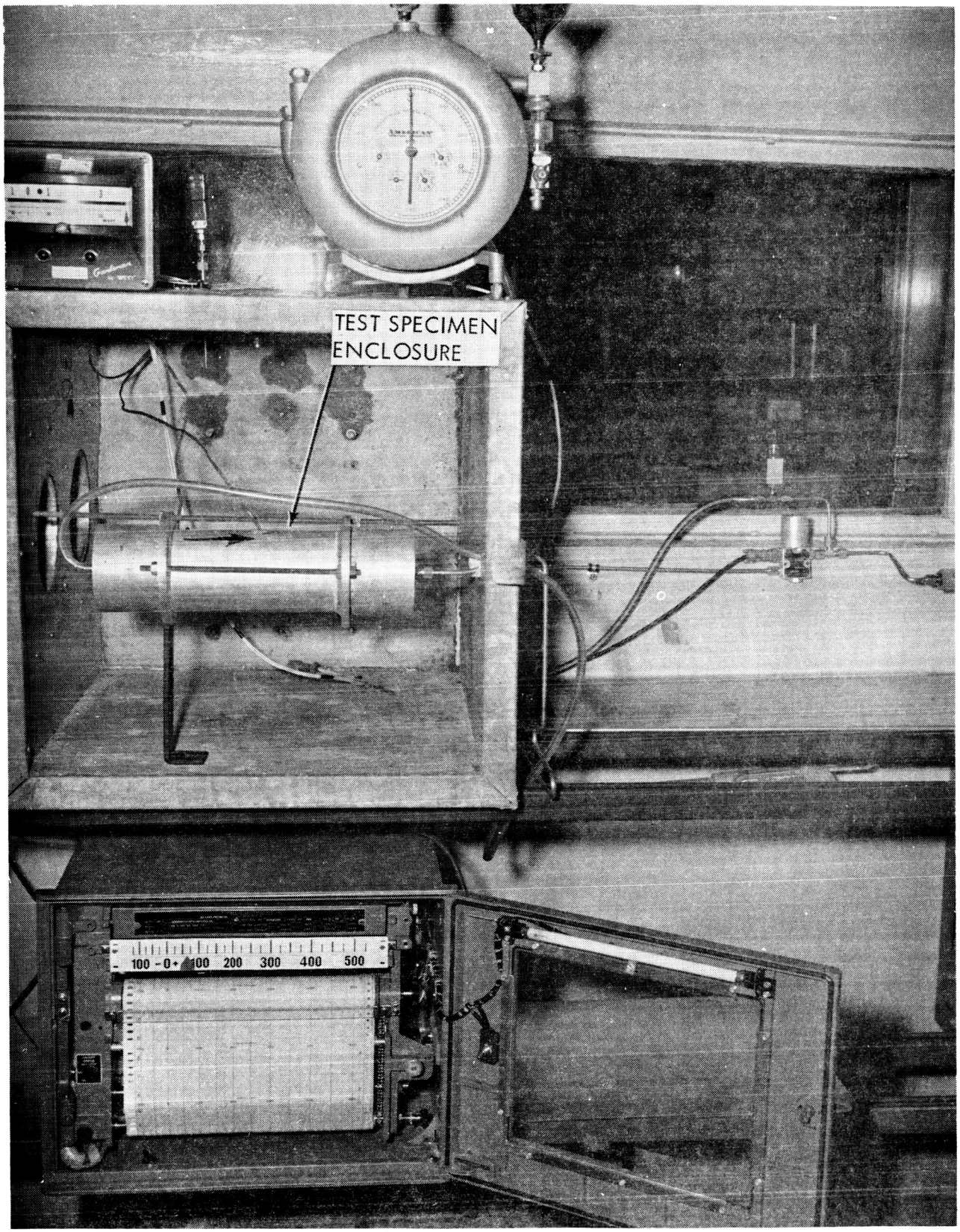


Figure 5-2. Low and High Temperature Test Setup

SECTION VI

HIGH TEMPERATURE TEST

6.1 TEST REQUIREMENTS

6.1.1 A high temperature test shall be performed on the test specimens to determine whether the environment causes degradation or deformation: To establish the suitability of the gasket materials, and to determine the thermal effects upon the bubble point.

6.1.2 The specified high temperature is 160(+4, -0)°F.

6.1.3 A bubble point test shall be performed before (if 72 hours or more has elapsed since the previous bubble point test), during, and within 1 hour following the test.

6.2 TEST PROCEDURE

6.2.1 Each test specimen was placed in a high temperature chamber as shown in figures 5-1 and 5-2. Utilizing the equipment listed in table 5-1.

6.2.2 The temperature within the chamber was controlled at 160(+4, -0)°F. While a relative humidity of 15 to 25 per cent was maintained.

6.2.3 Pressure regulator 5 was adjusted for zero outlet pressure.

6.2.4 With hand valve 2 open each specimen was pressurized to 6000 psig for 72 hours using pressure regulator 5. Specimen leakage was continuously monitored during the interval.

6.2.5 Hand valve 2 was closed and the pressure reduced to zero using regulator 5.

6.2.6 The specimen was removed from the chamber and the filter element separated from the body.

6.2.7 The element was then placed in the bubble point test setup.

6.2.8 The temperature of the filter element and the solox 190 was raised to 160(+4, -0)°F. A bubble point test was performed at this temperature.

6.2.9 The specimen and test medium were allowed to return to ambient conditions and a bubble point test conducted.

6.2.10 All test data were recorded.

6.3 TEST RESULTS

6.3.1 No leakage was observed from either specimen during the 72-hour test.

6.3.2 The bubble point test at high temperature showed an increase in the micron rating.

6.4 TEST DATA

The data presented in tables 6-1 and 6-2 were recorded during and after the 160°F environment.

Table 6-1. Leakage During High Temperature Test

Test Specimen	Leakage (scim)
1	None
2	None

Table 6-2. Bubble Point Test Data (High Temperature Test)

Test Specimen	Micron Rating (Microns)					
	Before High Temperature		@ High Temperature		After High Temperature	
	209 Constant	188 Constant	209 Constant	188 Constant	209 Constant	188 Constant
1	35.4	38.3	43.5	42.0	36.6	41.6
2	33.7	36.9	43.5	49.5	33.7	39.2

SECTION VII

FLOW TEST

7.1 TEST REQUIREMENTS

7.1.1 A flow test shall be performed on each pneumatic filter with 10-cfm air or gaseous nitrogen at 6000 psig to determine the flow characteristics of each specimen when exposed to varied inlet pressures. The pressure drop shall not exceed approximately 2 psi at the specified flow.

7.1.2 Sufficient data shall be obtained to plot flow versus pressure drop and flow versus inlet pressure.

7.2 TEST PROCEDURE

7.2.1 A bubble point test was performed.

7.2.2 Each specimen was installed in a test setup as shown in figures 7-1 and 7-2 utilizing the equipment listed in table 7-1.

7.2.3 Pressure regulator 5 was adjusted to zero outlet pressure.

7.2.4 Hand valve 2 was opened and hand valve 16 closed.

7.2.5 Using regulator 5, the test system was pressurized to 6000 psig as indicated on gages 8 and 11.

7.2.6 Inputs from pressure transducers 7, 10, 13, and 14 were calibrated to strip chart recorder 17.

7.2.7 The flow test was performed by opening downstream valve 16 and increasing the specimen inlet pressure from zero to 6000 psig. A curve of flow versus inlet pressure was plotted.

7.2.8 To develop a curve of flow versus ΔP, hand valve 16 was closed. Specimen inlet pressure was increased to 6000 psig. Hand valve 16 was cracked to approximately 10 per cent of the maximum flow recorded in 7.2.7. This was repeated until the maximum flow was reached.

7.2.9 The procedure described in 7.2.8 was repeated with inlet pressures of 5000, 4000, 3000, 2000, and 1000 psig.

7.2.10 Hand valve 2 was closed upon completion of the test.

7.2.11 The system was vented through pressure regulator 5.

7.2.12 All test data were recorded.

7.2.13 Data were reduced and curves of flow in scfm versus inlet pressure in psig and flow in scfm versus pressure drop in psi were plotted.

7.3 TEST RESULTS

Test results indicate the 2-psi allowable pressure drop at 10 cfm and 6000 psig to be totally unrealistic. Data obtained during this test were substantiated by comparing them with data taken during a flow test on a 20-micron permanent filter. Results of this test are shown in CCSD Technical Memorandum No. HSM-M006, page 121.

7.4 TEST DATA

7.4.1 Bubble point test results are presented in table 7-2.

7.4.2 Filter flow characteristics are presented in figure 7-3 through 7-6.

Table 7-1. Flow Test Equipment List

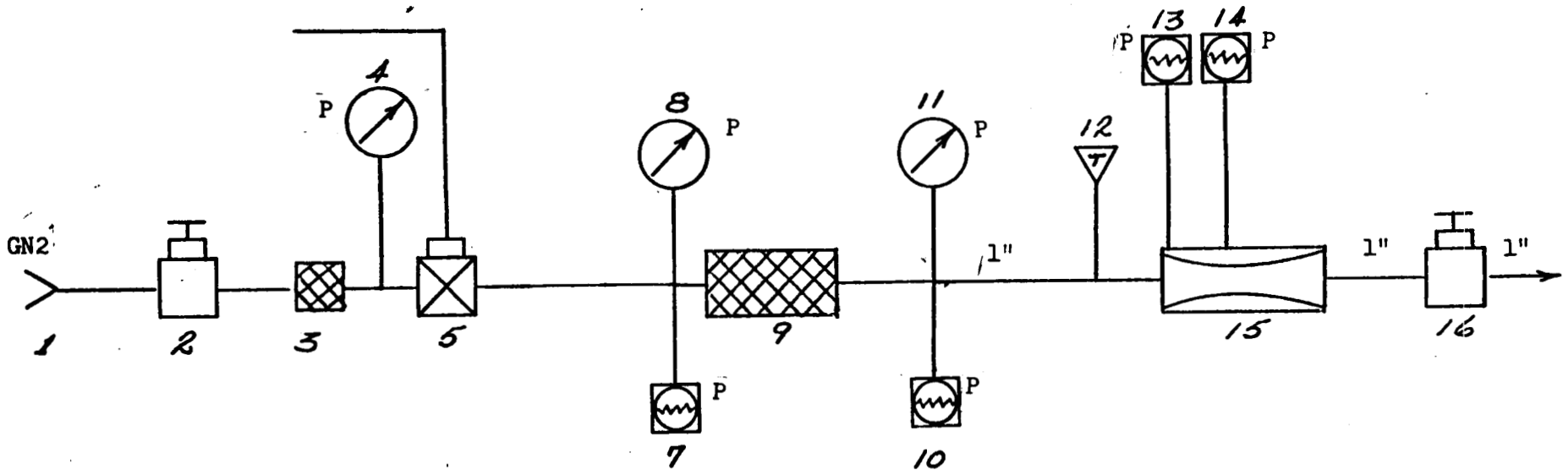
Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Supply	Laboratory Supply Cardair	NA	NA	9500-psig
2	Hand Valve	Cardair	3510-007	NA	10,000-psig
3	Filter	Fluid Dynamics	FL02-888	4066.	2-micron
4	Pressure Gage	Ashcroft	NA	NASA 95-1508-B	0-10,000 psig ±2% FS accuracy Cal date 4/7/67
5	Dome Loaded Pressure Regulator	Grove	201B	RA-7049	10,000-psig outlet
7	Pressure Transducer	Statham	PG-285TC-5M-350	34195	0-to 7500-psig max. Cal date 1/21/67
8	Pressure Gage	Heise	H35439	NA	0-to 10,000-psig, ± 2% FS accuracy Cal date 11/26/66
9	Test Specimen	Permanent Filter Corp.	10813	NA	Pneumatic Filter 3/8-inch
10	Pressure Transducer	Statham	PG-285TC-5M-350	34196	0-to 7500-psig max. Cal date 1/21/67
11	Pressure Gage	Heise	H38640	NA	0-to 10,000-psig, ±2% FS accuracy, Cal date 11/26/66
12	Temperature Probe		NA	NA	Copper Constantan
13	Pressure Transducer	Statham	12210	NA	0-to 9500-psig Cal date 1/21/67

Table 7-1. Flow Test Equipment List (Continued)

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
14	Pressure Transducer	Teledyne	176	652137	0-to 10,000-psig Cal date 12/22-66
15	Venturi Flow-Meter	Flowdyne Engr.	XV160200-SA	2319	Original calibration only
16	Hand Valve	Vacco Valve	NV-6P-403 2G	5176-10	0-to 6000-psig

Table 7-2. Bubble Point Test Results Obtained

Before Flow Test		
Test Specimen	Micron Rating (Microns)	
	209 Constant	188 Constant
2	38.0	44.8
3	37.4	41.7



Note: All lines 3/8 inch except where otherwise indicated.
Refer to table 7-1 for item identification.

Figure 7-1. Flow Test Schematic

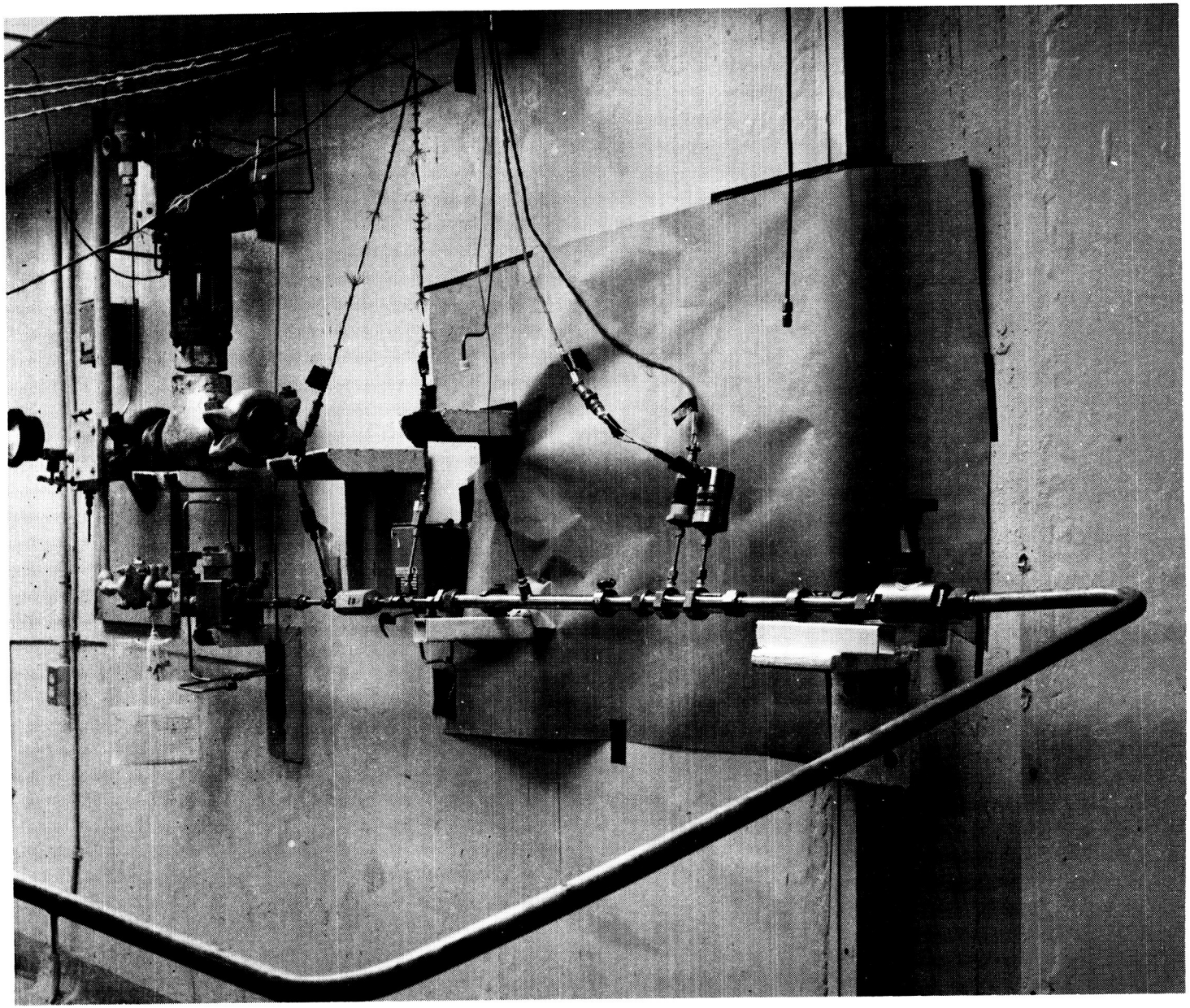


Figure 7-2. Flow Test Setup

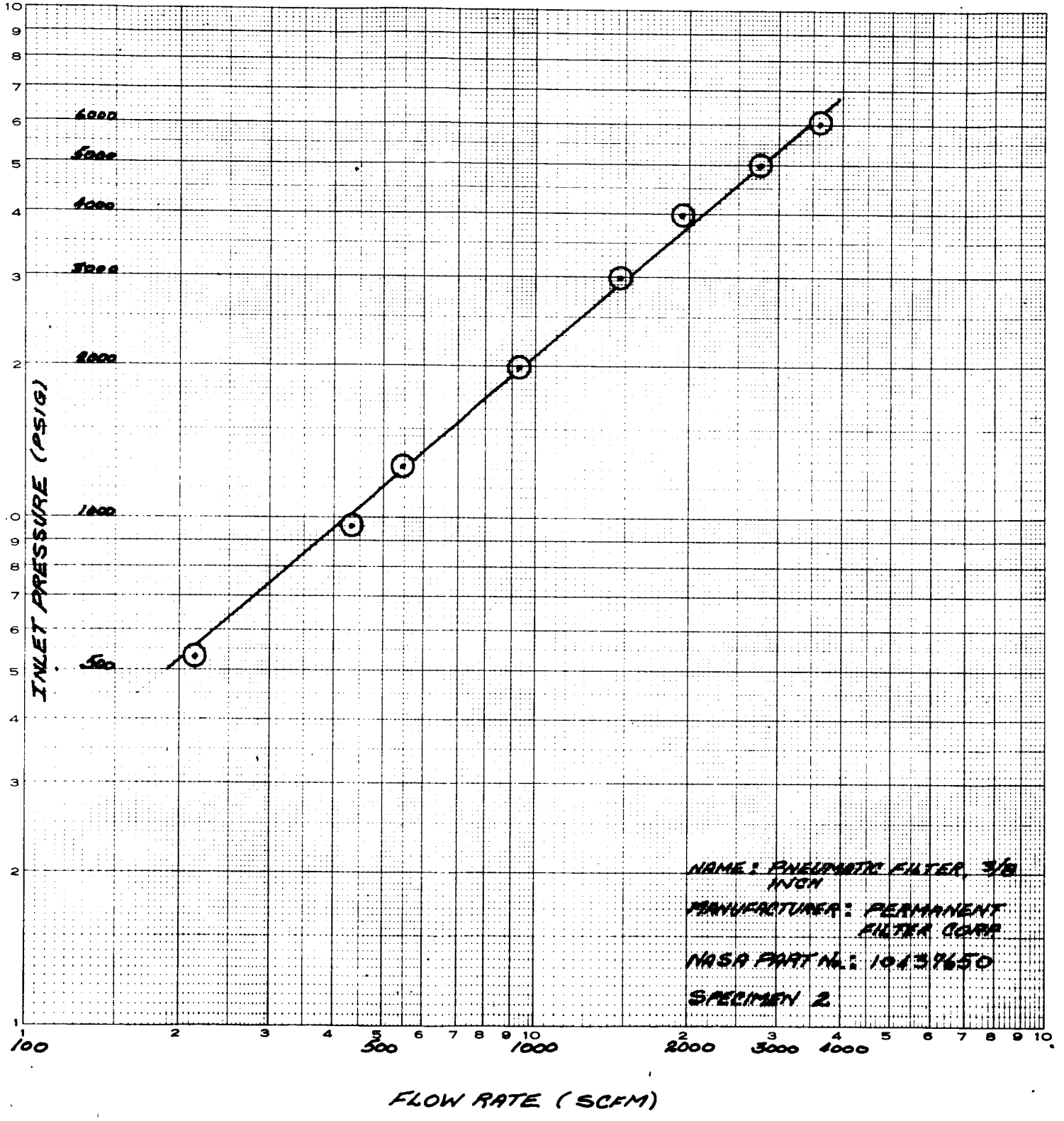


Figure 7-3. Flow Rate Versus Inlet Pressure, Specimen 2

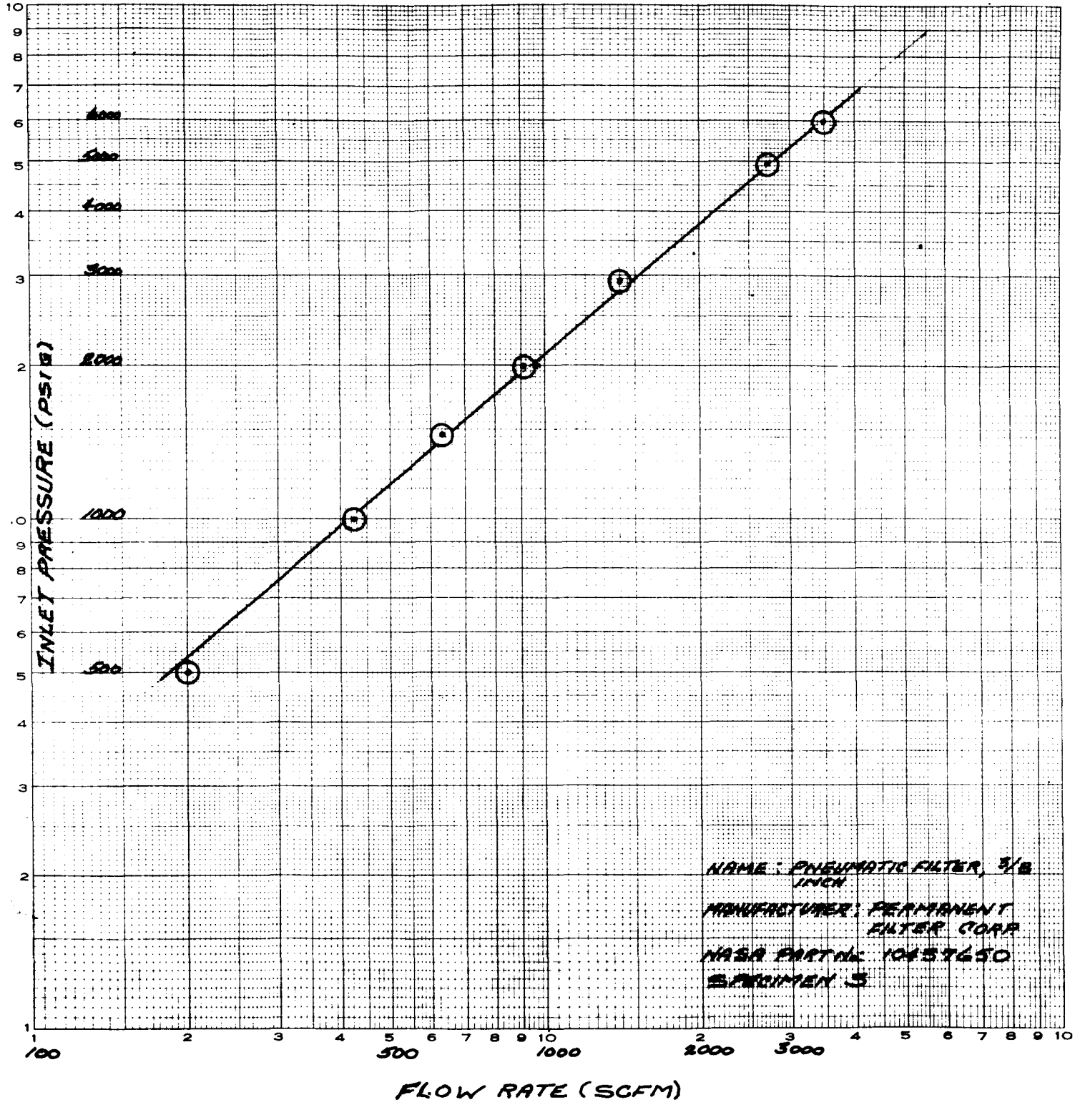


Figure 7-4. Flowrate Versus Inlet Pressure, Specimen 3

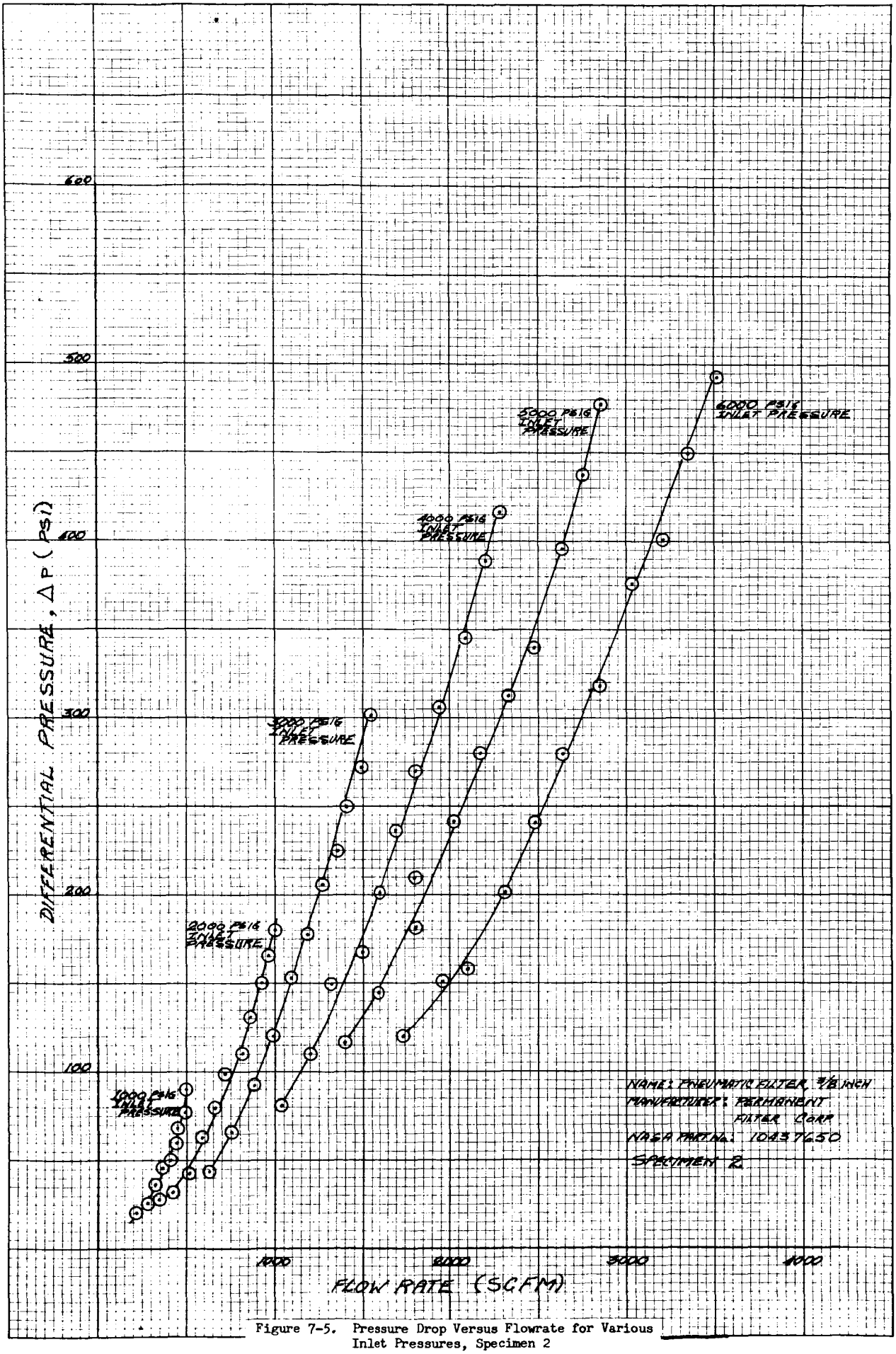


Figure 7-5. Pressure Drop Versus Flowrate for Various Inlet Pressures, Specimen 2

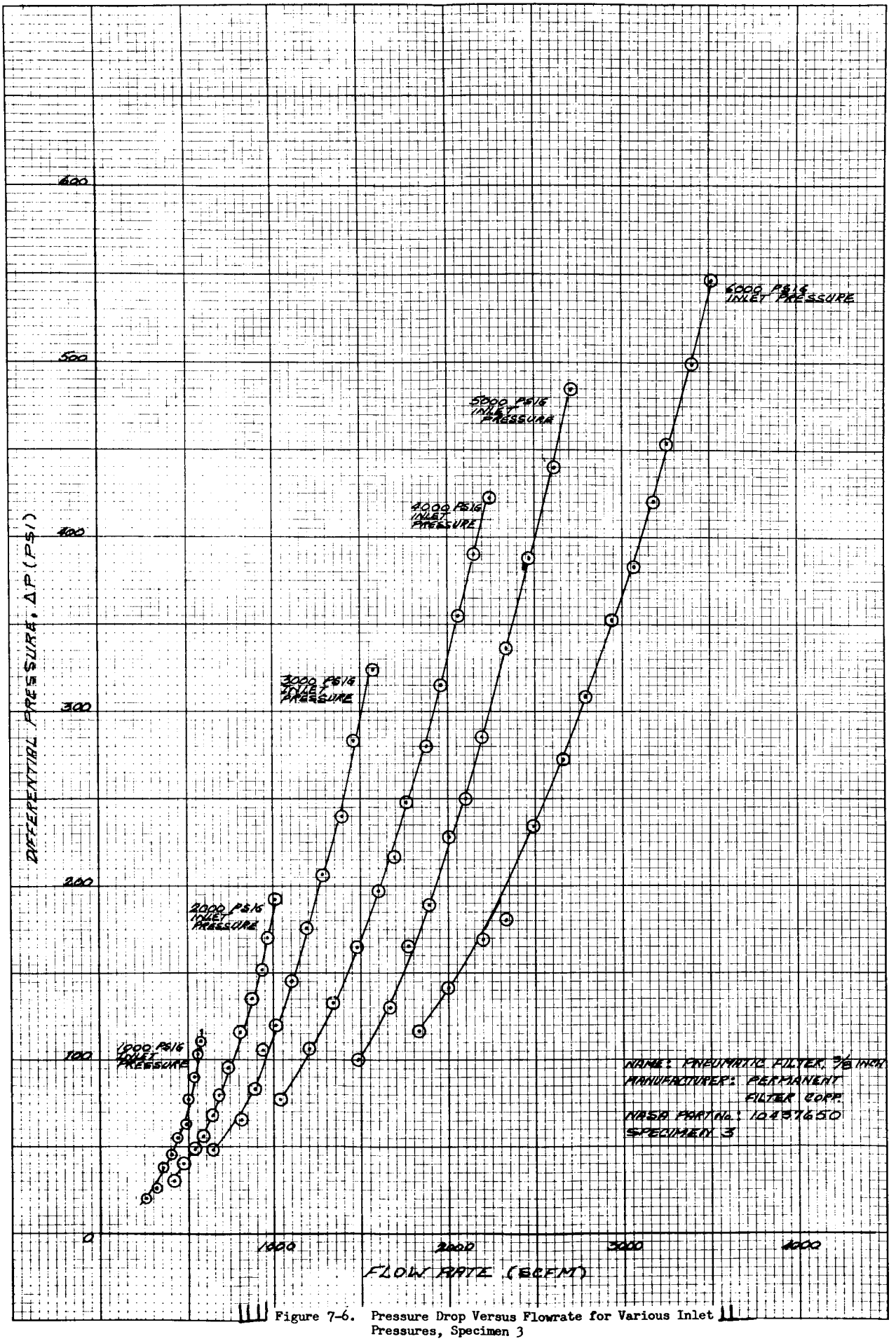


Figure 7-6. Pressure Drop Versus Flowrate for Various Inlet Pressures, Specimen 3

SECTION VIII

SURGE TEST

8.1 TEST REQUIREMENTS

With air or GN_2, apply pressure surges from 0 to 6000 psig to the upstream side of the filter to verify its structural integrity. Each test specimen shall be subjected to 1000 pressure surges with the pressure time rise not to exceed 100 milliseconds.

8.2 TEST PROCEDURE

8.2.1 The test specimens were installed in a test setup as shown in figures 8-1 and 8-2. Utilizing the equipment listed in table 8-1.

8.2.2 Solenoid valve 6 and hand valve 12 were opened. Regulator 5 was adjusted to zero outlet pressure.

8.2.3 Hand valves 2 and 8 were opened.

8.2.4 The system was pressurized using regulator 5 until gage 9 indicated 6000 psig.

8.2.5 Pressure transducer 10 was calibrated to oscillograph 12.

8.2.6 The system was vented to zero pressure through solenoid valve 6. Hand valve 9 was closed.

8.2.7 Cycling was started by energizing the timer and counter.

8.2.9 One-thousand pressure surges from 0 to 6000 psig were performed with each surge having a rise time of less than 100 milliseconds.

8.2.10 Hand valve 2 was closed and the entire system vented to zero pressure using pressure regulator 5 and solenoid valve 6.

8.2.11 The setup was disassembled and the filter element removed from the body.

8.2.12 A bubble point test was performed.

8.2.13 All test data were recorded.

8.3 TEST RESULTS

8.3.1 The pressure surges produced no apparent deformation or distortion to the filter housing or the elements.

8.3.2 The bubble point test after the surge test showed no significant increase in the micron rating.

8.4 TEST DATA

8.4.1 Typical surge pressure traces are presented in figure 8-3.

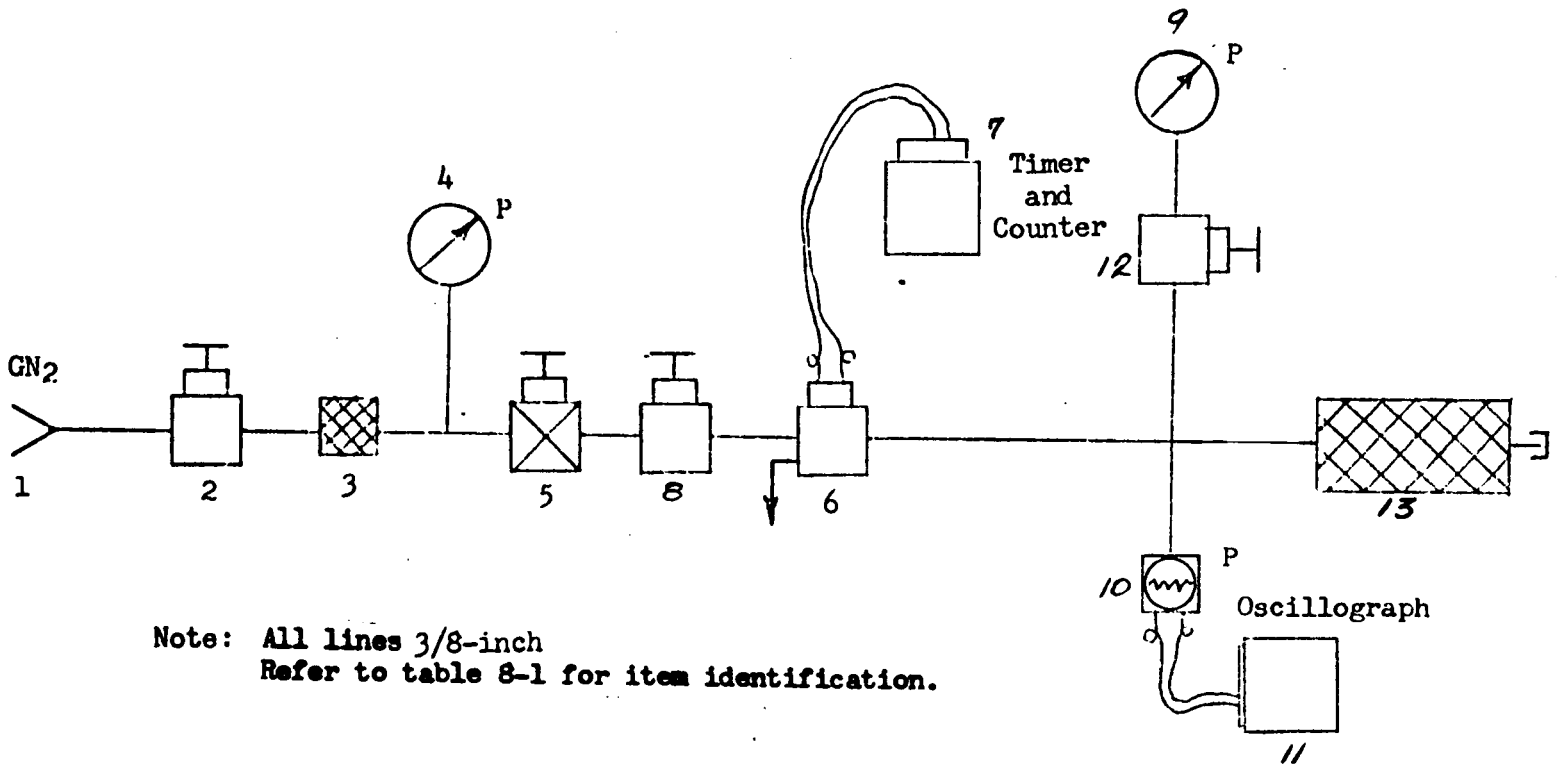
8.4.2 Bubble point test data are presented in table 8-2.

Table 8-1. Surge Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Source	Laboratory Supply	NA	NA	9500-psig
2	Hand Valve	Aminco	13126	NA	1/2-inch
3	Filter	Microporous	4813F-2DM	NA	2-micron absolute
4	Pressure Gage	Ashcroft	NA	NASA 95-1508 -B	0-to 10,000-psig ±2% FS accuracy Cal. date 4/7/67
5	Pressure Regulator	Tescom	26-1021-20	NA	10,000-psig outlet
6	Solenoid Valve	Marotta	801-514-2	370	6000-psig, 3-way
7	Timer and Counter	CCSD and G.C. Wilson	No.1	NA	±0.005-second unit count
8	Hand Valve	Marsh Instrument Co.	1936FFG	NA	3/8-inch
9	Pressure Gage	Ashcroft	NA	NASA 95-1583-B	0-to 10,000-psig, ±2% FS accuracy Cal date 3/12/67
10	Pressure Transducer	Statham	12210	NA	7500-psig Cal Date 1/21/67
11	Oscillograph	Consolidated Electrodynamics	5-124	NA	Cal date 12/5/66
12	Hand Valve	Robbins Aviation	SKG-250-4T	NA	1/4-inch
13	Test Specimen	Permanent Filter Corp.	10813	NA	Pneumatic Filter, 3/8-inch

Table 8-2. Bubble Point Test Data (Surge Test)

Test Specimen	Micron Rating (Microns)			
	Before Surge Test		After Surge Test	
	209 Constant	188 Constant	209 Constant	188 Constant
2	37.1	42.0	38.0	44.8
3	36.6	43.0	37.4	41.8



Note: **All lines** 3/8-inch
Refer to table 8-1 for item identification.

Figure 8-1. Surge Test Schematic

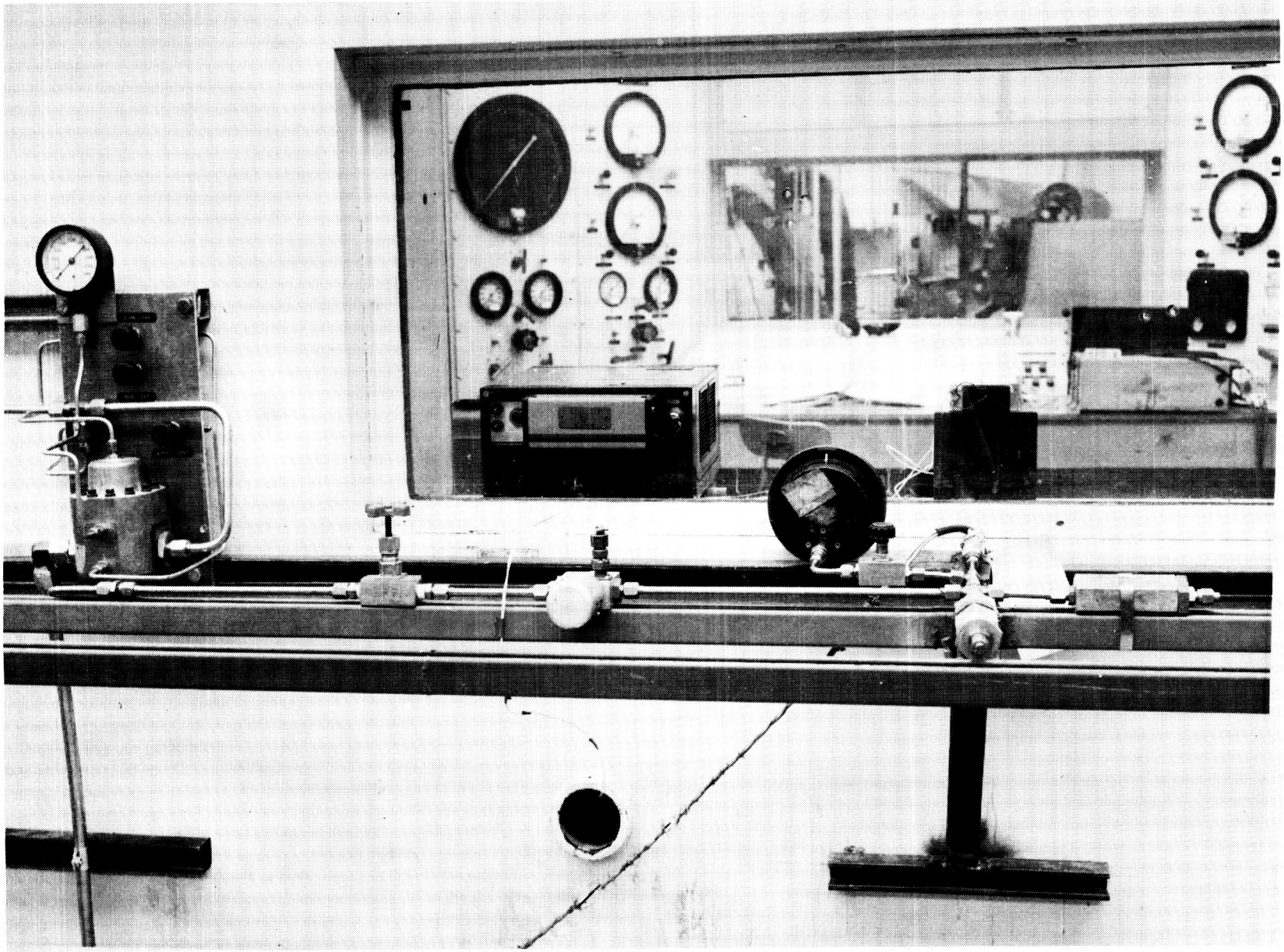


Figure 8-2. Surge Test Setup

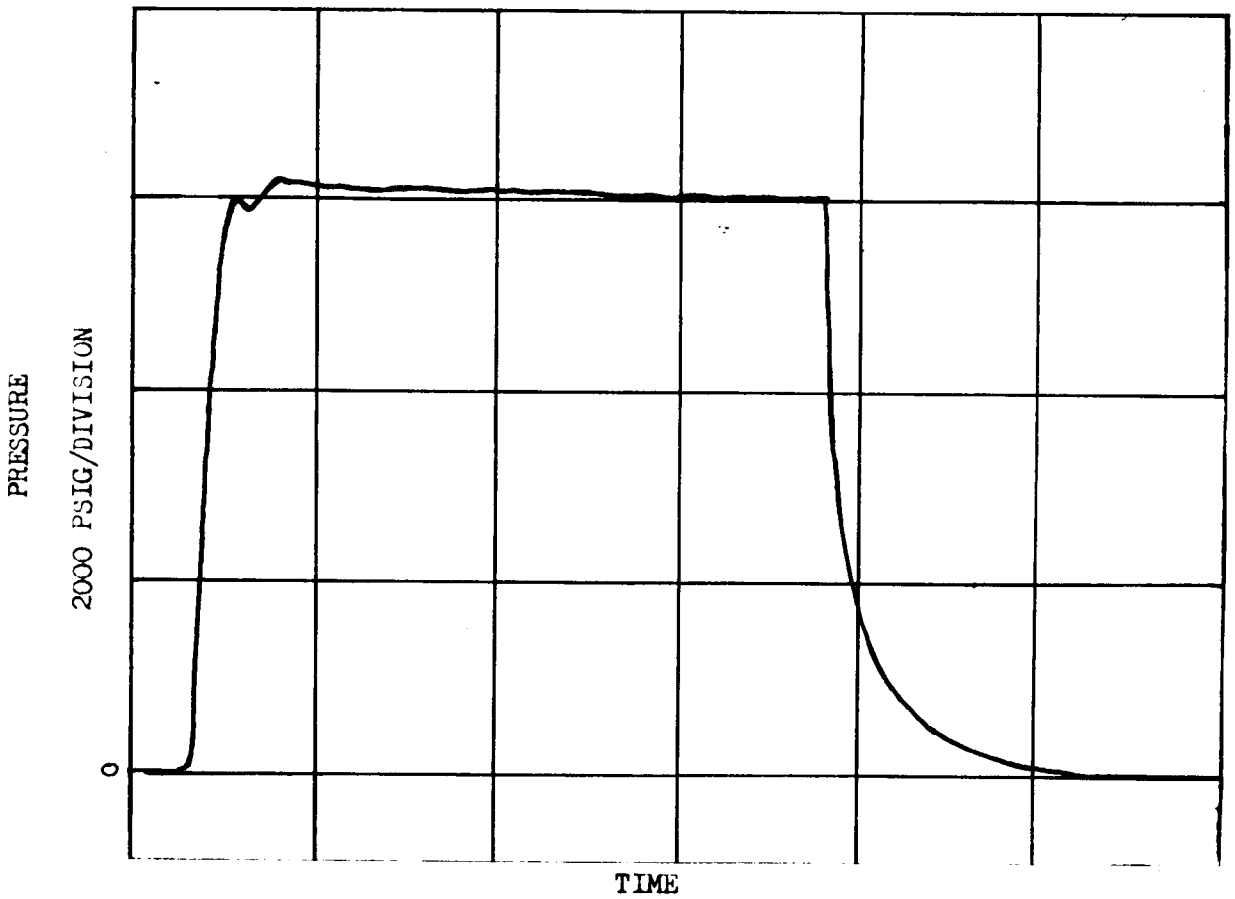


Figure 8-3. Typical Surge Pressure Trace

SECTION IX

VIBRATION TEST

9.1 TEST REQUIREMENTS

9.1.1 A vibration test shall be performed to determine whether the environment causes degradation or deformation. Testing shall be performed in accordance with KSC-STD-164(D), section 9, figures 9-1 and 9-2, level D.

9.1.2 RESONANT FREQUENCY SEARCH

9.1.2.1 The fixture/test specimen assembly shall be exposed to sinusoidal vibration at the input levels shown in table 9-1. A frequency range of 5 to 3000 cps shall be traversed logarithmically in directions of both increasing and decreasing frequency over a time period not to exceed 15 minutes per axis. Actual time shall be noted. All fixture and test specimen resonant frequencies and the structural member in resonance shall be noted. In addition, critical frequencies of each test specimen shall be noted. Critical frequencies are defined as those frequencies at which functional or structural degradation occurs.

Table 9-1. Resonant Frequency Search Levels

Frequency (cps)	Displacement (DA inch)	Acceleration (g)
5 to 45	0.01	NA
45 to 3000	--	1.0

9.1.3 SINUSOIDAL SWEEP

9.1.3.1 In one 20-minute sweep, the frequency range shall be scanned logarithmically from 10 to 2000 cps and back to 10 cps. Critical frequencies of each test specimen shall be noted. The sinusoidal sweep input levels shall be as shown in table 9-2.

Table 9-2. Sinusoidal Sweep Vibration Levels

Frequency (cps)	Displacement (DA inch)	Acceleration (g)
10 to 45	0.1	NA
45 to 2000	NA	10

9.1.4 RANDOM EXCITATION

9.1.4 Each test specimen shall be exposed to random vibration at the specified levels over a frequency range from 10 to 2000 cps for 5 minutes. The specified random levels shall be as shown in table 9-3.

Table 9-3. Random Excitation Vibration Levels

Frequency (cps)	Slope (db/octave)	PSD (g^2/cps)
10 to 100	+6	NA
100 to 1000	NA	0.01
1000 to 2000	-6	NA

9.1.4.2 Acceleration shall be measured at the test assembly by accelerometers mounted on the assembly.

9.1.4.3 The vibration test shall be conducted in two mutually perpendicular axes. The previously described testing is for one axis and shall be completed before proceeding to the next axis.

9.2 TEST PROCEDURE

9.2.1 Resonant frequency search

9.2.1.1 The test specimen was mounted on the vibration fixtures as shown in figures 9-1 and 9-2 utilizing the equipment listed in table 9-4.

9.2.1.2 Pressure regulator 5 was adjusted to zero outlet pressure.

9.2.1.3 Hand valve 2 was opened.

9.2.1.4 Using regulator 5, the system was pressurized until pressure gage 10 indicated 5000 psig.

9.2.1.5 The frequency range from 5 to 3000 cps and back to 5 cps was scanned logarithmically over a time period which did not exceed 15 minutes in one axis. Input levels are shown in table 9-1.

9.2.1.6 All resonant frequencies were recorded.

9.2.2 SINUSOIDAL SWEEP TEST

9.2.2.1 The frequency range from 10 to 2000 cps and back to 10 cps was scanned logarithmically over a period of 20 minutes in one axis. Input levels are shown in table 9-2. All resonant frequencies were recorded.

9.2.2.2 Hand valve 2 was closed and the system vented to zero pressure through regulator 5.

9.2.3 A bubble point test was performed before proceeding with random vibration.

9.2.4 Random Excitation Test

9.2.4.1 The procedure described in 9.2.1.1 to 9.2.1.4 were repeated.

9.2.4.2 Each test specimen was subjected to a random excitation for 5 minutes in each axis. The specified random input levels are shown in table 9-3.

9.2.4.3 The procedure described in 9.2.2.2 was repeated.

9.2.5 A bubble point test was performed.

9.2.6 The procedure described in 9.2.1 through 9.2.5 were repeated for the next axis.

9.3 TEST RESULTS

9.3.1 No major resonant frequencies were noted below 2000 cps in the X-axis.

9.3.2 The only major resonant frequency recorded during the Z-axis sweep occurred at approximately 1800 cps.

9.3.3 Vibration testing had little effect on the micron rating.

9.4 TEST DATA

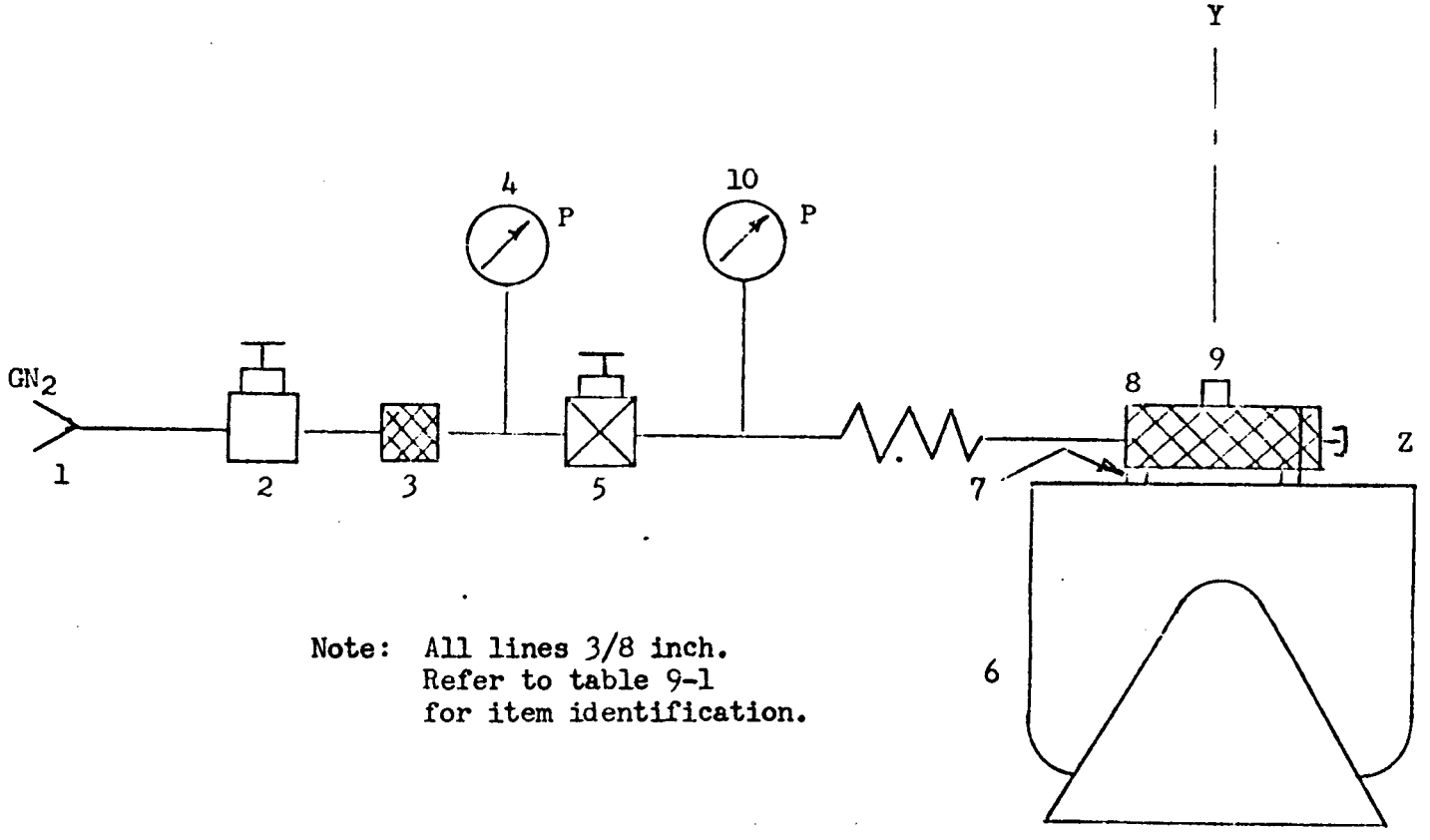
9.4.1 Control accelerometer input plots are presented in figures 9-3 through 9-6.

9.4.2 Resonance in the Z-axis is presented in figure 9-7.

9.4.3 Bubble point test data are presented table 9-5.

Table 9-4. Vibration Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Supply	Laboratory Supply	NA	NA	6500-psig
2	Hand Valve	Combination Pump and Valve Co	380-4	NA	1-1/2-inch
3	Filter	Bendix	1731620	NA	2-micron absolute
4	Pressure Gage	Ashcroft	1057S	NA	0 to 5000 psig ±2% FS accuracy Cal date 11/20/66
5	Pressure Regulator	Tescom	26-1109-162	421	10,000-psig outlet
6	Vibration Exciter	MB	C-10E	731	1000-force-lb
7	Vibration Test Fixture	CCSD	NA	NA	
8	Test Specimen	Permanent Filter Corp.	10813	NA	Pneumatic filter, 3/8-inch
9	Accelerometer	Endevco Corp.	2233 2220	NC74 LT25 LD77	Control and response, Cal date 11/23/66
10	Pressure Gage	Ashcroft	NA	NASA-95-1583-B	0 to 10,000-psig, ±2% FS accuracy Cal date 3/12/67



Note: All lines 3/8 inch.
Refer to table 9-1
for item identification.

Figure 9-1. Vibration Test Schematic

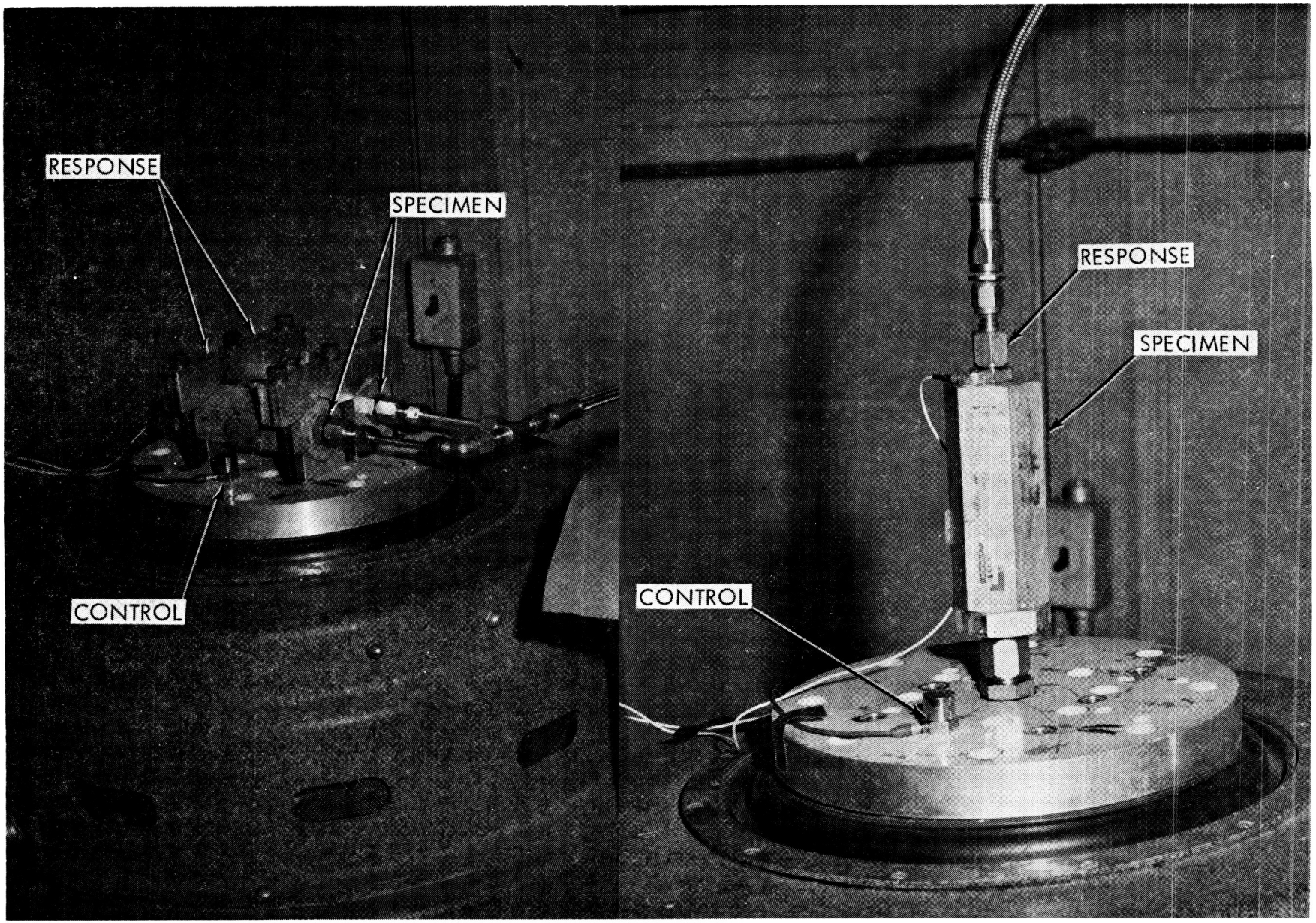


Figure 9-2. Vibration Test Setup, X and Z Axes

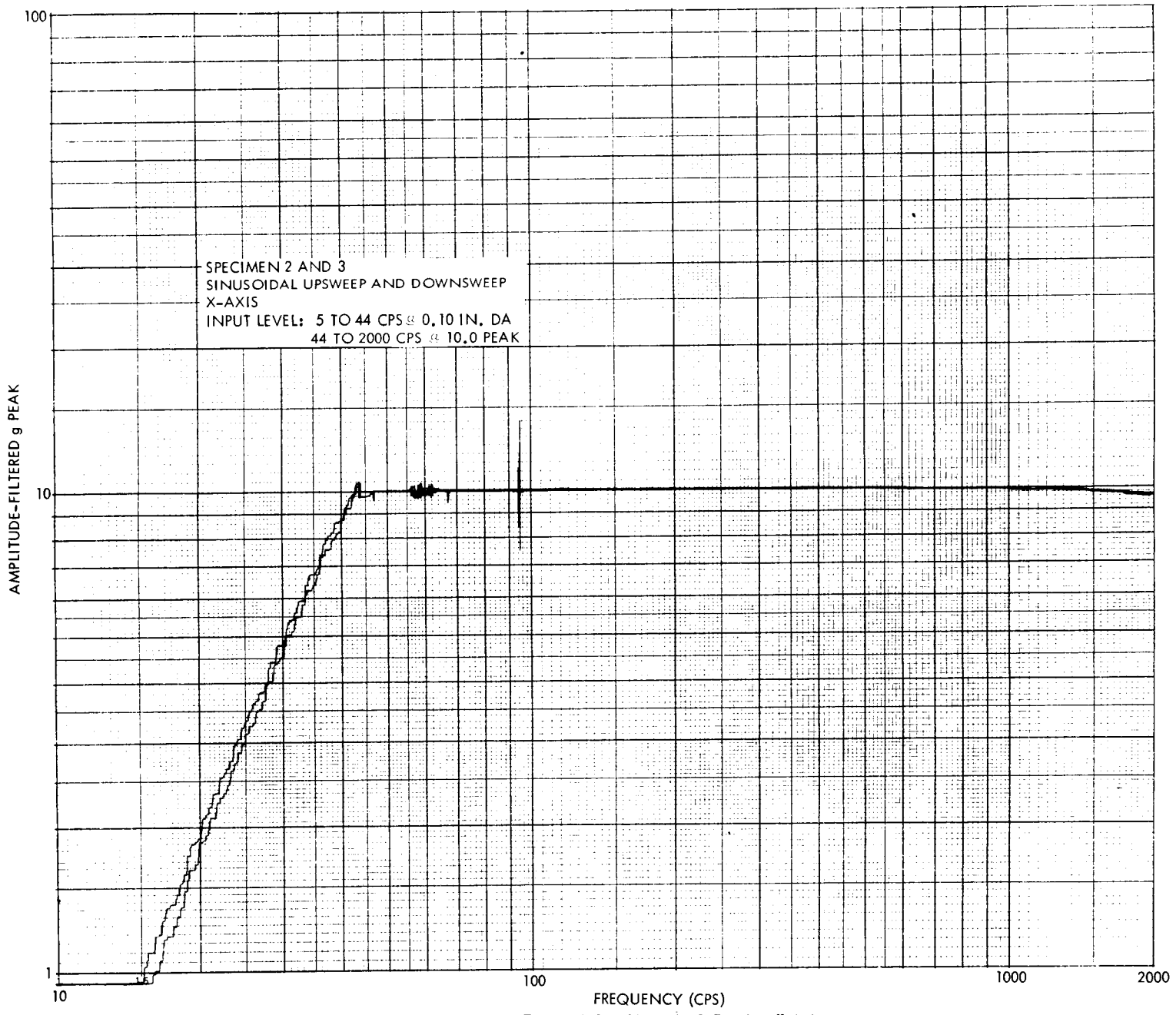


Figure 9-3. Sinusoidal Inputs, X-Axis

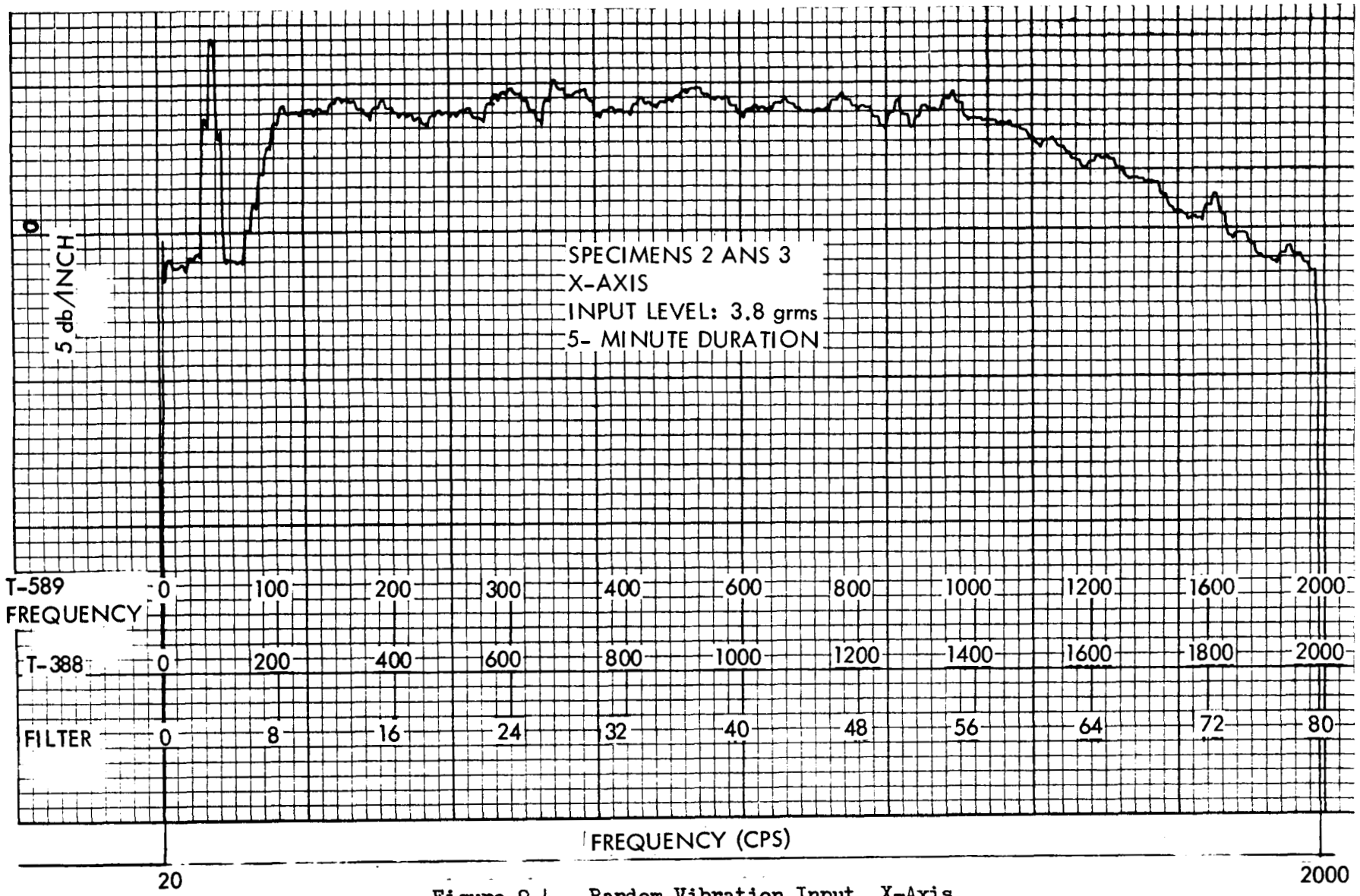


Figure 9-4. Random Vibration Input, X-Axis

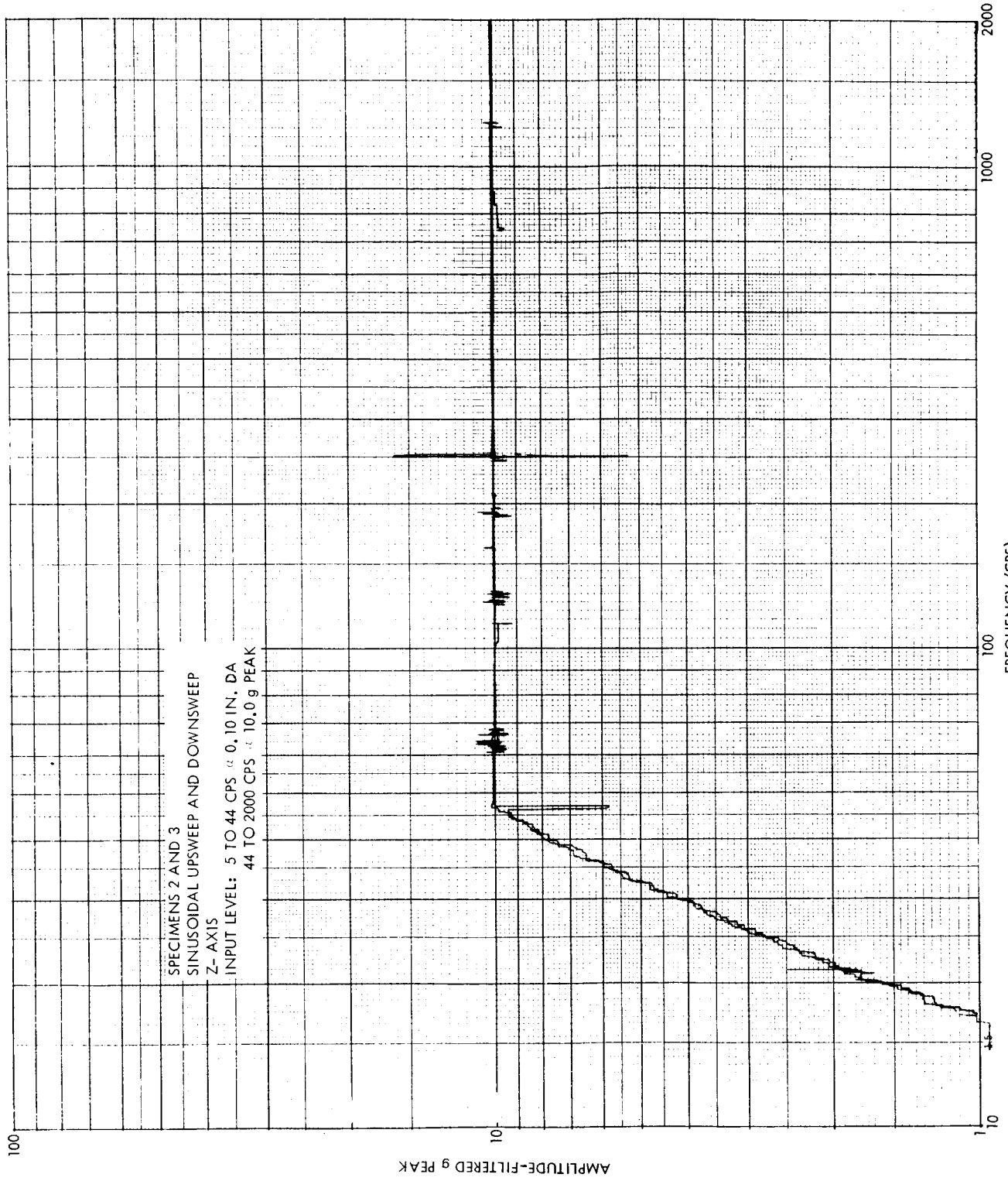


Figure 9-5. Sinusoidal Inputs, Z-Axis

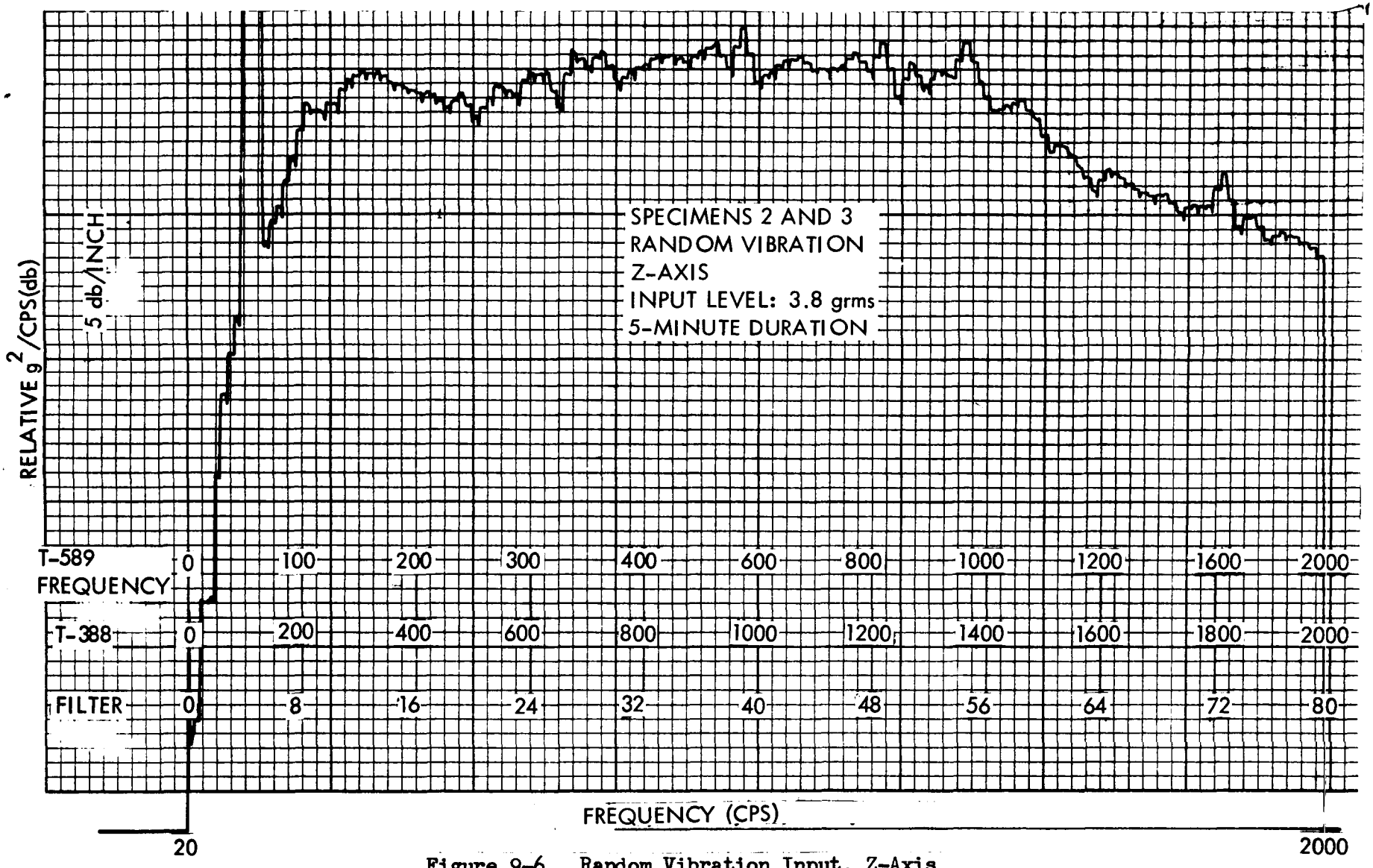


Figure 9-6. Random Vibration Input, Z-Axis

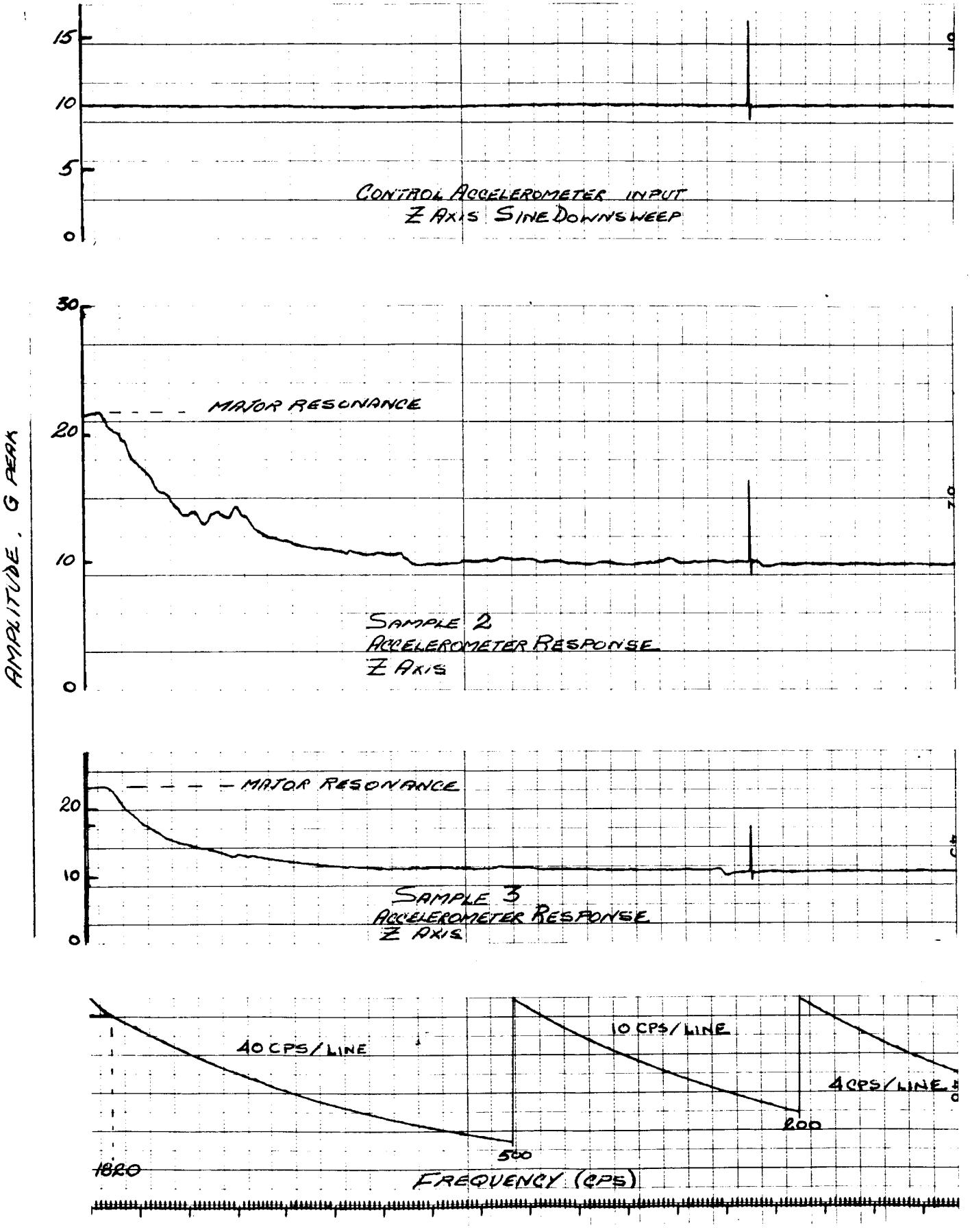


Figure 9-7. Z-Axis Resonance

SECTION X

SALT FOG TEST

10.1 TEST REQUIREMENTS

10.1.1 A salt fog test shall be performed to determine the extent, if any, of the degradation or deterioration of the housing resulting from the environmental exposure.

10.1.2 The test shall be conducted in accordance with section 17 of KSC-STD-164(D).

10.1.3 The salt solution shall be a 5 per cent by weight of salt and 95 parts by weight of water.

10.1.4 Test temperature shall be 95 (+2, -4)°F.

10.1.5 The solution shall have pH factor of 6.5 to 7.2.

10.1.6 A proof pressure test shall be performed on the filter body before and after exposure to this environment.

10.1.7 Procedures described 4.2 shall be requirements of this test.

10.2 TEST PROCEDURE

10.2.1 A bubble point test was performed.

10.2.2 The inlet and outlet ports of each specimen were capped.

10.2.3 Each specimen was inspected for corrosion dirt, and oily film. Any corrosion was noted. The exterior of each specimen was washed with freon TF and rinsed in deionized water immediately prior to installing in the test chamber.

10.2.4 Each specimen was placed in the chamber in a manner so as to permit the fog to reach all sides of the filter body but so as to reduce the possibility of condensate dripping on the bodies.

10.2.5 Each specimen was exposed to 240 hours of salt fog atmosphere with a salt solution of 5 per cent by weight, a temperature of 95 (+Z, -4)°F, and a collection rate of 0.5 to 3 milliliters per hour.

10.2.6 At the completion of the test each specimen was inspected for deterioration and degradation.

10.2.7 A bubble point test was performed.

10.2.8 All test data were recorded.

10.3 TEST RESULTS

10.3.1 There was no noticeable external degradation or deterioration.

10.3.2 The salt fog test had little effect on the micron rating of each specimen.

10.4 TEST DATA

Bubble point test data are presented in table 10-1.

Table 10-1. Bubble Point Test Data (Salt Fog Test)

Test Specimen	Micron Rating (Microns)			
	Before Salt Fog		After Salt Fog	
	209 Constant	188 Constant	209 Constant	188 Constant
1	34.8	43.7	37.3	40.9
2	36.7	47.0	41.0	41.8

SECTION XI

DIRT HOLDING AND COLLAPSE PRESSURE TEST

11.1 TEST REQUIREMENTS

11.1.1 Coarse air cleaner dust shall be added to each filter in 0.5-gram slurries while flow is maintained at 10 cfm and 6000 psig.

11.1.2 Dust shall be added in increments to each filter element until the element collapses or the pressure drop across the filter assembly becomes constant.

11.2 TEST PROCEDURE

11.2.1 A bubble point test was performed.

11.2.2 Each filter assembly was installed in a test setup as shown in figures 11-1 and 11-2 utilizing the equipment listed in table 11-1.

11.2.3 With solenoid valve 6 closed, pressure regulator 5 was adjusted to zero outlet pressure.

11.2.4 Hand valve 2 was opened and hand valve 16 closed.

11.2.5 With solenoid valve 6 open, the system was pressurized to 6000 psig using regulator 5.

11.2.6 Pressure transducers 7, 10, 13, and 14 were calibrated to the strip chart recorder.

11.2.7 Regulator 5 and hand valve 16 were adjusted until a flow of 8.95 cfm at 6000 psig was obtained at the specimen inlet. This was the maximum amount of flow obtainable due to system and supply limitations. Pressure drop across the filter was recorded.

11.2.8 The system flow and pressure were reduced to zero using regulator 5 and solenoid 6.

11.2.9 The cap was removed from the dust-add device and 0.5 gram of coarse air cleaner test dust was inserted. The cap was replaced.

11.2.10 Regulator 5 was adjusted to the pressure required in 11.2.7. Solenoid 6 was then opened.

11.2.11 Contaminant added Δ P and were recorded.

11.2.12 The procedures described in 11.2.8 through 11.2.11 were repeated until the Δ P (difference between pressure indicated by transducers 7 and 10) became constant or the element collapse.

11.2.13 All test data were recorded.

11.2.14 Hand valve 2 was closed and the system vented to zero using regulator 5.

11.2.15 Contaminant added versus ΔP was plotted.

11.3 TEST RESULTS

The filter elements of the specimens collapsed during the test at nearly the same ΔP, however, approximately 66 per cent more test dust was required to collapse specimen 2 than to collapse specimen 3.

11.4 TEST DATA

11.4.1 Bubble point data obtained prior to this test are presented in table 11-2.

11.4.2 Contaminant added versus ΔP is presented in figure 11-3.

11.4.3 The filter element, showing collapse, is presented in figure 11-4.

Table 11-1. Dirt Holding and Collapse Pressure Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Supply	Laboratory Supply	NA	NA	9500-psig
2	Hand Valve	Cardair	3510-007	NA	10,000-psig
3	Filter	Fluid Dynamics	FL02-888	4066	2-micron
4	Pressure Gage	Ashcroft	NA	NASA 95-1508-B	0-to 10,000-psig ±2% FS accuracy Cal date 4/7/67
5	Dome Loaded Pressure Regulator	Grove	201 B	RA-7049	10,000-psig outlet
6	Solenoid Valve	Marotta	MV510H	190	0-to 6000-psig
7	Pressure Transducer	Statham	PG-285TC-5M-350	34195	0-to 7500-psig max Cal date 1/21/67
8	Pressure Gage	Heise	H35439	NA	0-to 10,000-psig ±2% FS accuracy Cal date 11/26/66
9	Test Specimen	Permanent Filter Corp.	10813	NA	Pneumatic Filter 3/8-inch
10	Pressure Transducer	Statham	PG-285TC-5M-350	34196	0-to 7500-psig max Cal date 1/21/67
11	Pressure Gage	Heise	H 38640	NA	0-to 10,000-psig ±2% FS accuracy Cal date 11/26/66
12	Temperature Probe				Copper Constantan
13	Pressure Transducer	Statham	12210		0-to 9500-psig Cal date 1/21/67

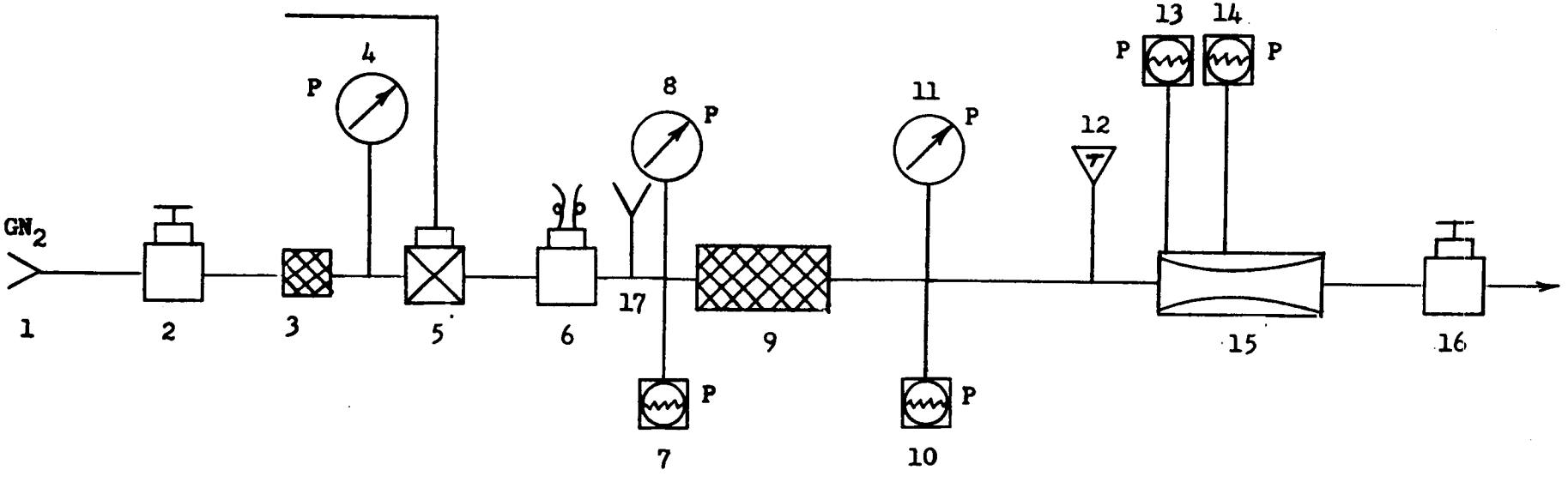
Table 11-1. Dirt Holding and Collapse Pressure Test Equipment List (Continued)

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
14	Pressure Transducer	Teledyne	176	652137	0-to 10,000-psig Cal date 12/22/ 66
15	Venturi Flowmeter	Flowdyne Engr.	XV160200-SA	2319	Original calibration only
16	Hand Valve	Yacco Valve	NV-6P-403 2G	5176-10	0-to 6000-psig
17	Dust-Add Device	CCSD			

Table 11-2. Bubble Point Test Data

(Dirt Holding and Collapse Pressure Test)

Specimen	Micron Rating (Microns)	
	209 Constant	188 Constant
2	37.3	42.7
3	38.8	42.7



NOTE: All lines 3/8-inch except where otherwise indicated.
Refer to table 11-1 for item identification.

Figure 11-1. Dirt Holding and Collapse Pressure Test Schematic

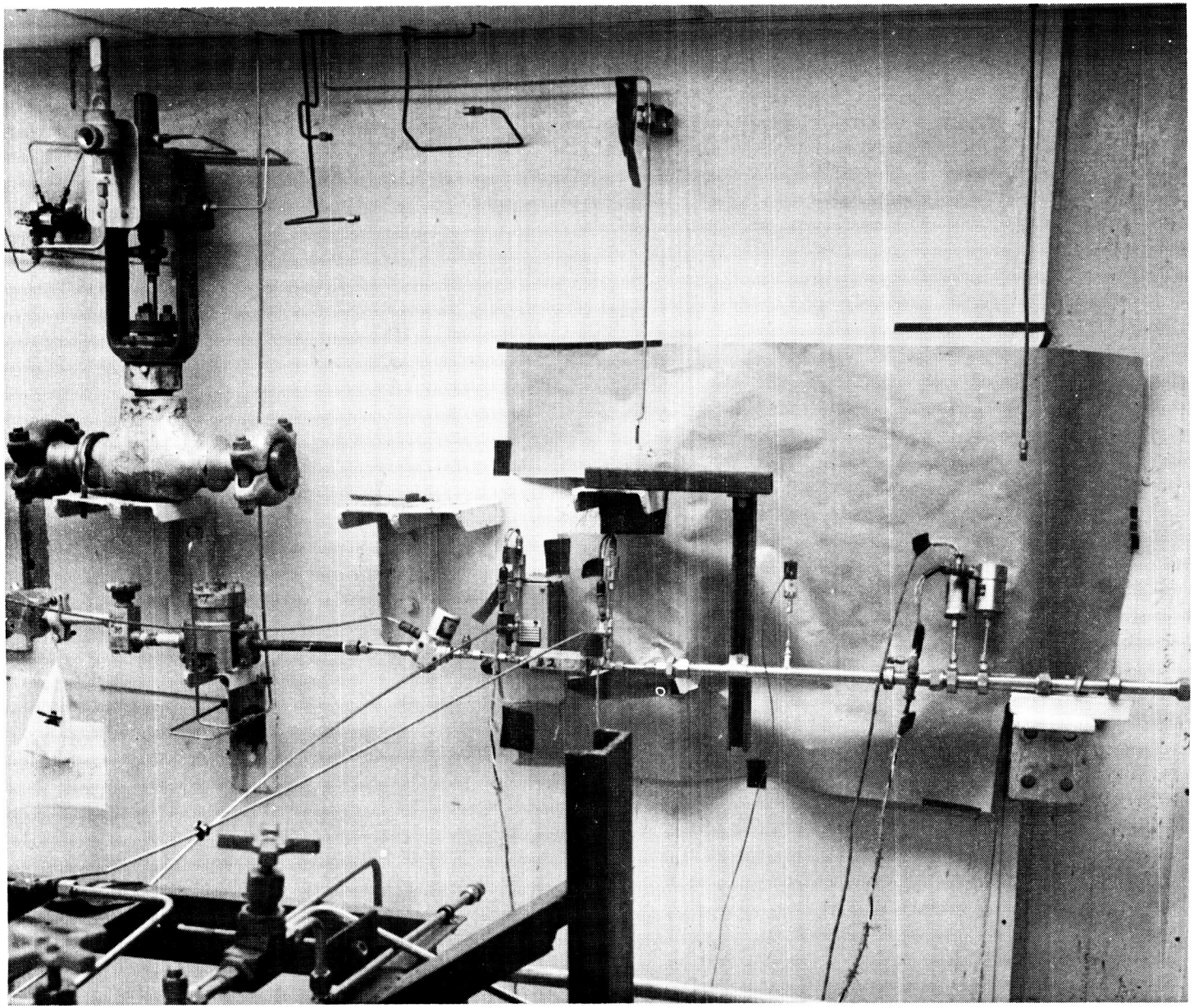


Figure 11-2. Dirt Holding and Collapse Pressure Test Setup

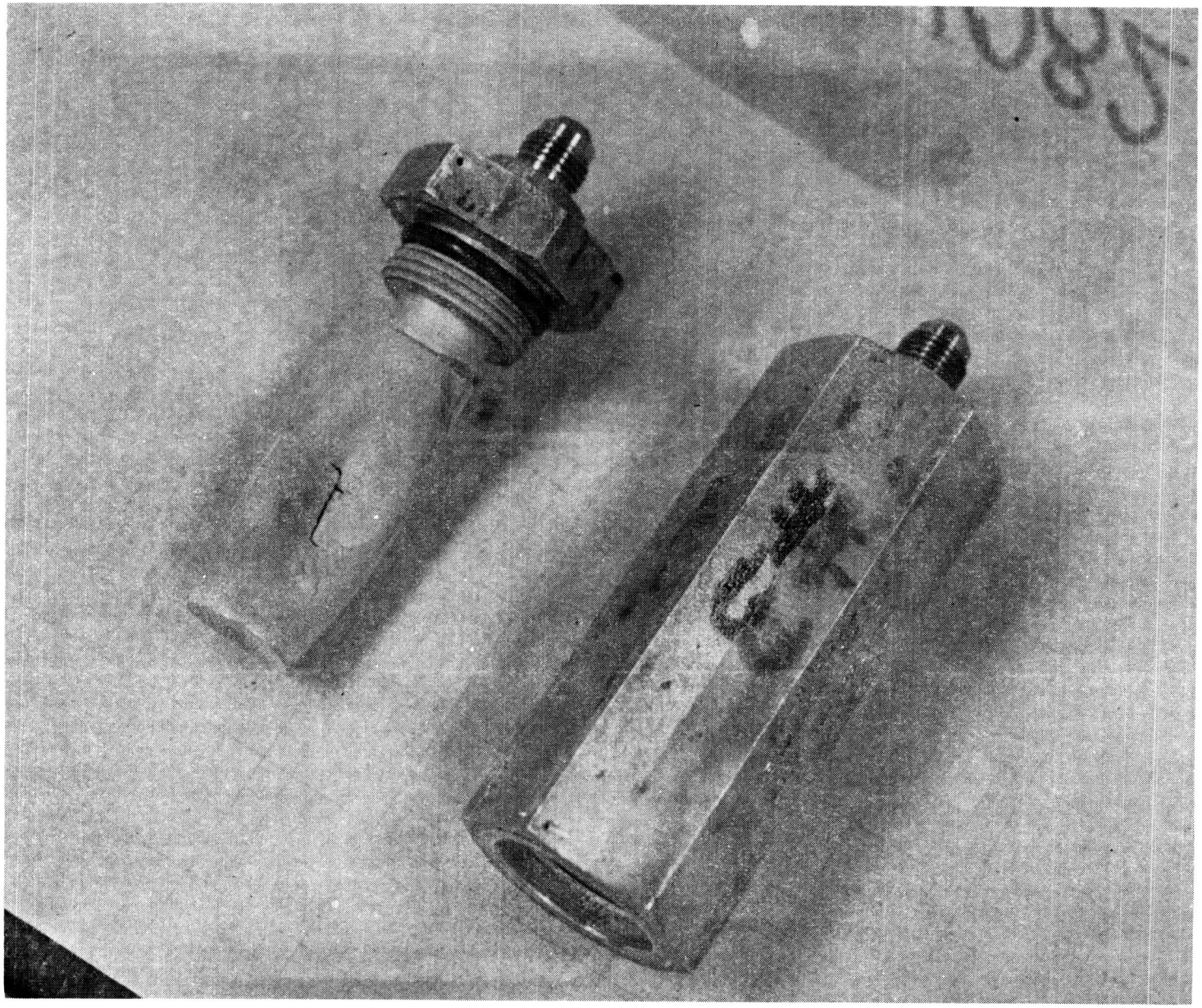


Figure 11-3. Filter Element Showing Collapse From Excessive Dif'erential Pressure

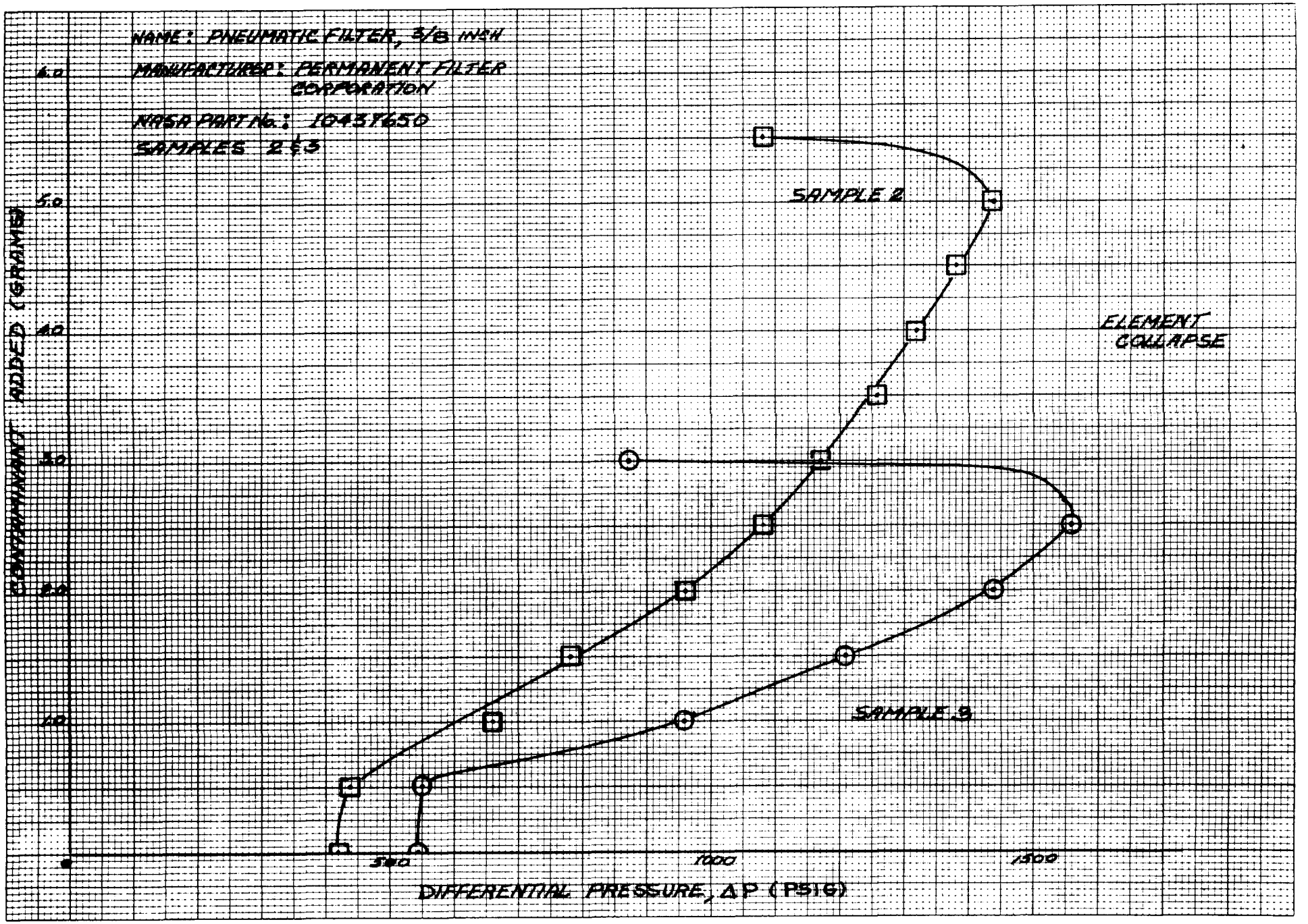


Figure 11-4. Differential Pressure Versus Contaminant Added

SECTION XII

FINAL INSPECTION

12.1 TEST REQUIREMENTS

A final inspection shall be performed on each specimen to ascertain the effects of testing.

12.2 TEST PROCEDURE

12.2.1 The exterior of each test specimen was examined for degradation or deterioration.

12.2.2 Each filter element was removed from its housing. The elements were examined for distortion collapse, mechanical failure, rubbing or chaffing, and condition of the threads, seals, and sealing surfaces.

12.2.3 No ultrasonic cleaning prior to inspection was necessary.

12.2.4 All observations were recorded.

12.3 TEST RESULTS

12.3.1 There was no noticeable degradation or deterioration of the exterior of any of the specimens.

12.3.2 The filter elements of specimens 2 and 3 collapsed during the previous test.

12.4 TEST DATA

No data were obtained.

SECTION XIII

BURST TEST

13.1 TEST REQUIREMENTS

13.1.1 Burst tests shall be performed to determine the structural integrity of each test specimen after completion of all reliability testing.

13.1.2 Each test specimen (filter body only) shall be capable of withstanding a pressure of 24,000 psig for 5 minutes.

13.2 TEST PROCEDURE

13.2.1 The filter body of each specimen was installed in the burst test setup as shown in figures 13-1 and 13-2 utilizing the equipment listed in table 13-1.

13.2.2 The outlet port of the filter was capped.

13.2.3 Pressure regulator 5 was adjusted to zero outlet pressure.

13.2.4 Hand valve 2 was opened.

13.2.5 The hydrostatic pump was pressurized using regulator 5.

13.2.6 Using the hydrostatic pump the filter housing of each specimen, was pressurized to 24,000 psig in less than 1 minute. Deionized water was used for this test. The pressure was maintained for 5 minutes.

13.2.7 The pressure was then reduced to zero with controls on the pump.

13.2.8 Hand valve 2 was closed and the pump supply pressure reduced to zero.

13.2.9 Each specimen was inspected for damage or distortion.

13.2.10 All test data were recorded.

13.3 TEST RESULTS

13.3.1 There was no noticeable damage or distortion to the filter housing of sample 1.

13.3.2 The housing of sample 2 showed a complete split in the longitudinal direction. It should be noted that the hydrostatic pump surged from 23,000 to 25,000 psig during its last cycle.

13.3.3 Sample 3 was subjected to a burst test because of the failure of sample 2. After 2 minutes at 24,000 psig the threaded cap blew out of the housing. An inspection of the cap showed that only three threads were in contact.

13.4 TEST DATA

13.4.1 Test data for the specimens are presented in table 3-2.

13.4.2 Sample 2 after failure is presented in figure 13-3.

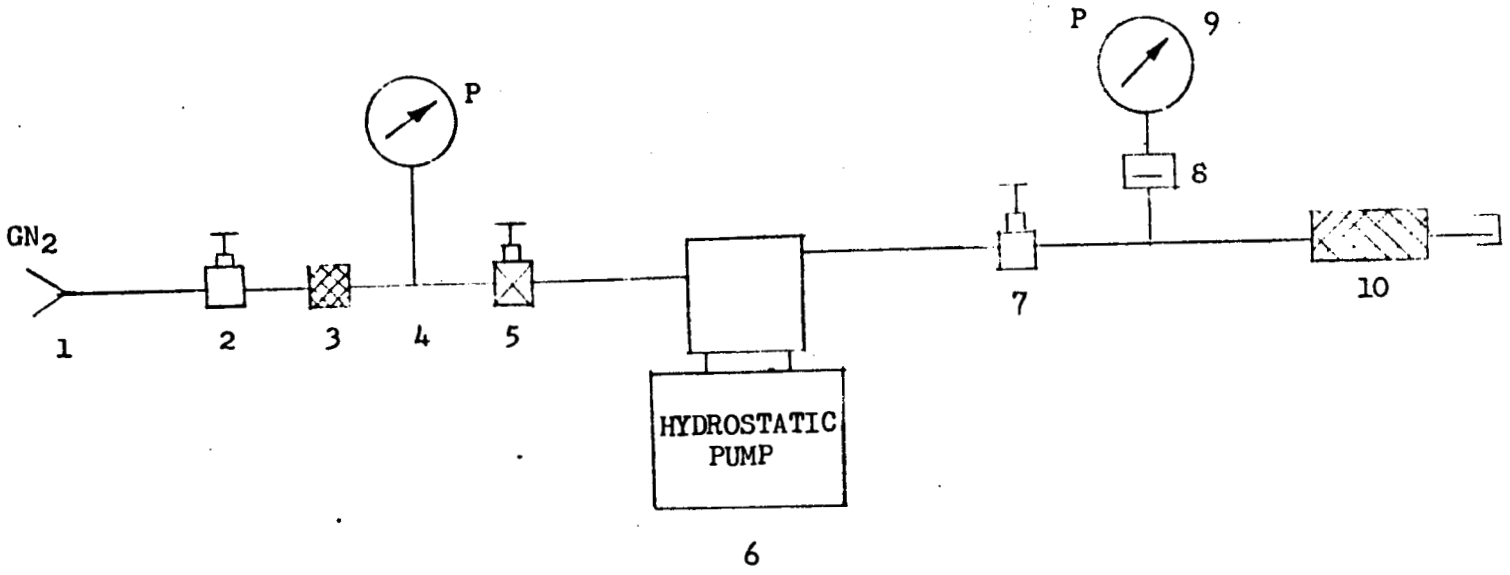
13.4.3 Sample 3 after failure is presented in figure 13-4.

Table 13-1. Burst Test Equipment List

Item No.	Item	Manufacturer	Model/ Part No.	Serial No.	Remarks
1	GN_2 Pressure Source	Laboratory Supply	NA	NA	
2	Hand Valve	Combination Pump and valve Co.	380-4	NA	1-1/2-inch
3	Filter	Bendix	1731260	NA	2-micron absolute
4	Pressure Gage	U.S. Gage	8990	NA	0-to 5000-psig, ±2% FS accuracy
5	Pressure Regulator	Marotta	NA	NA	10,000-psi inlet 300-psi outlet
6	Hydrostatic Pump	Sprague	NA	300-16-64	30,000-psig
7	Hand Valve	Aminco	44-13106	NA	1/4-inch 60,000-psig
8	Check Valve	Aminco	44-6305	NA	30,000-psig
9	Pressure Gage	Astra	NA	NASA-08 113 011893 A	0-to 100,000-psig, ± 0.25% FS accuracy Cal date 3/20/67
10	Test Specimen	Permanent Filter Corp.	10813	NA	Pneumatic filter, 3/8-inch

Table 13-2. Burst Test Data

Specimen	Pressure (psig)	Time (min.)	Results
1	24000	5	Satisfactory
2	23000 to 25000 (Surge)	0	Case Rupture
3	24000	2	Threads Sheared



Note: All line 3/8 inch. Refer to table 13-1 for item identification.

Figure 13-1. Burst Test Schematic

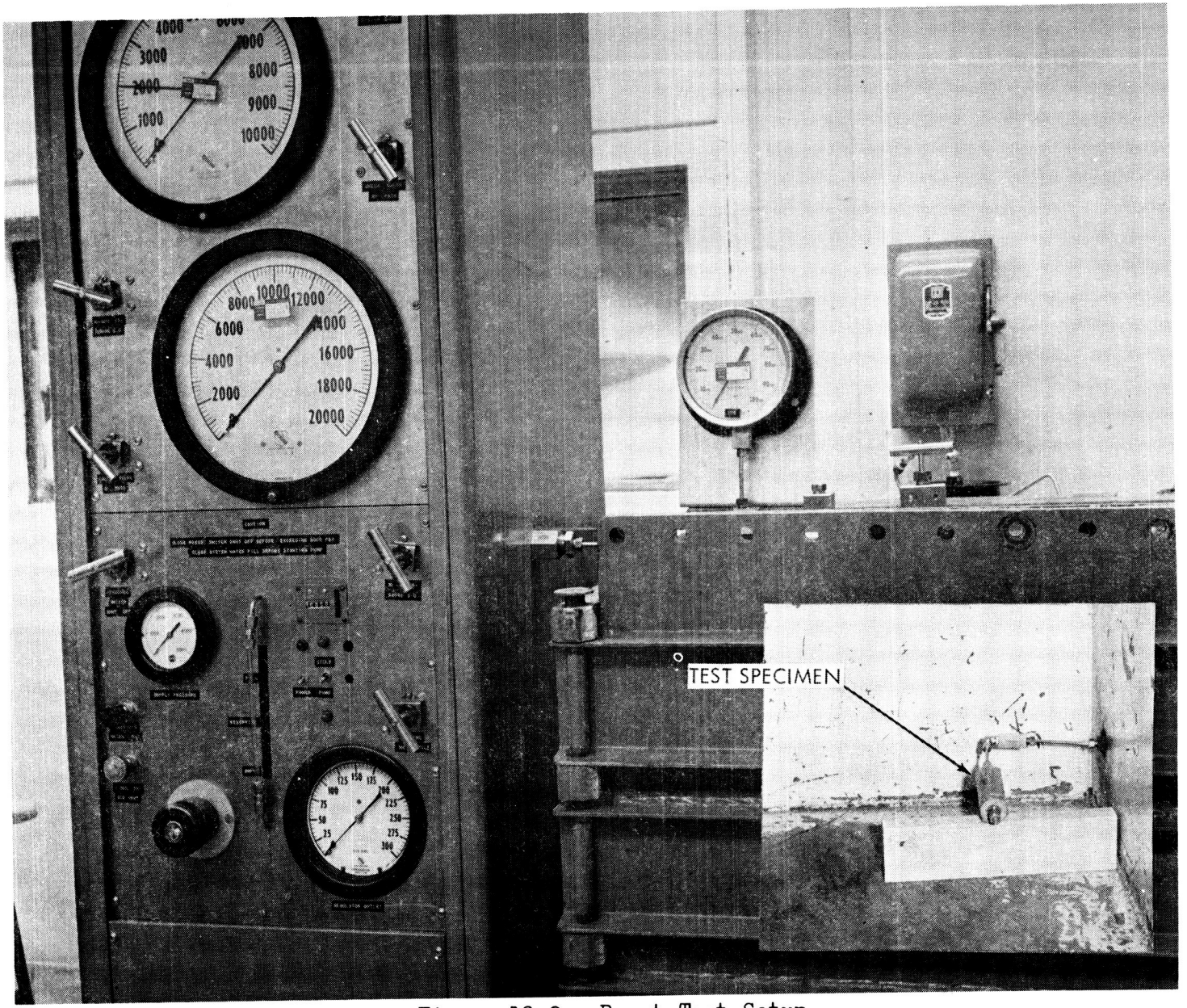


Figure 13-2. Burst Test Setup

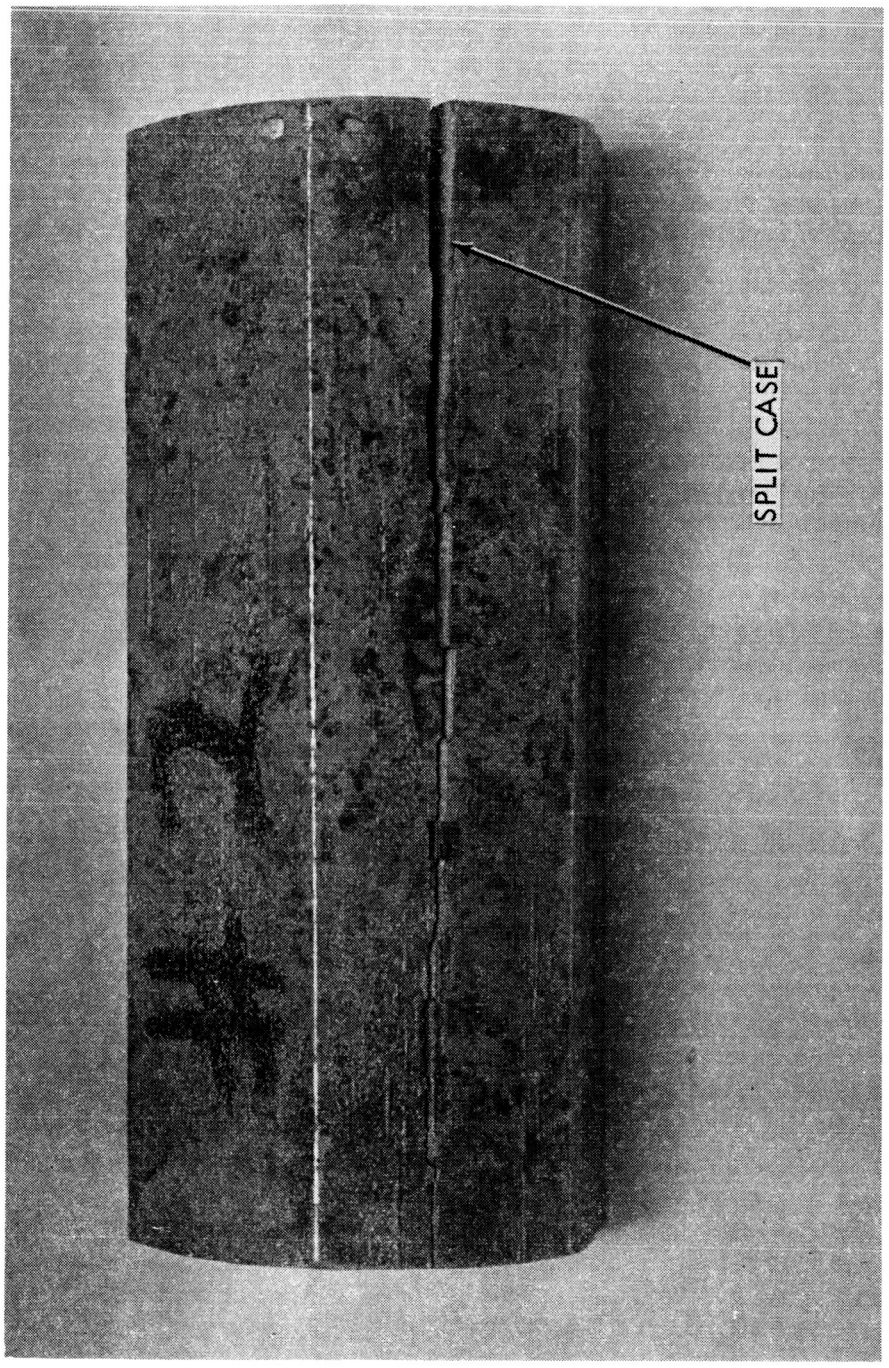


Figure 13-3. Case Failure on Specimen 2

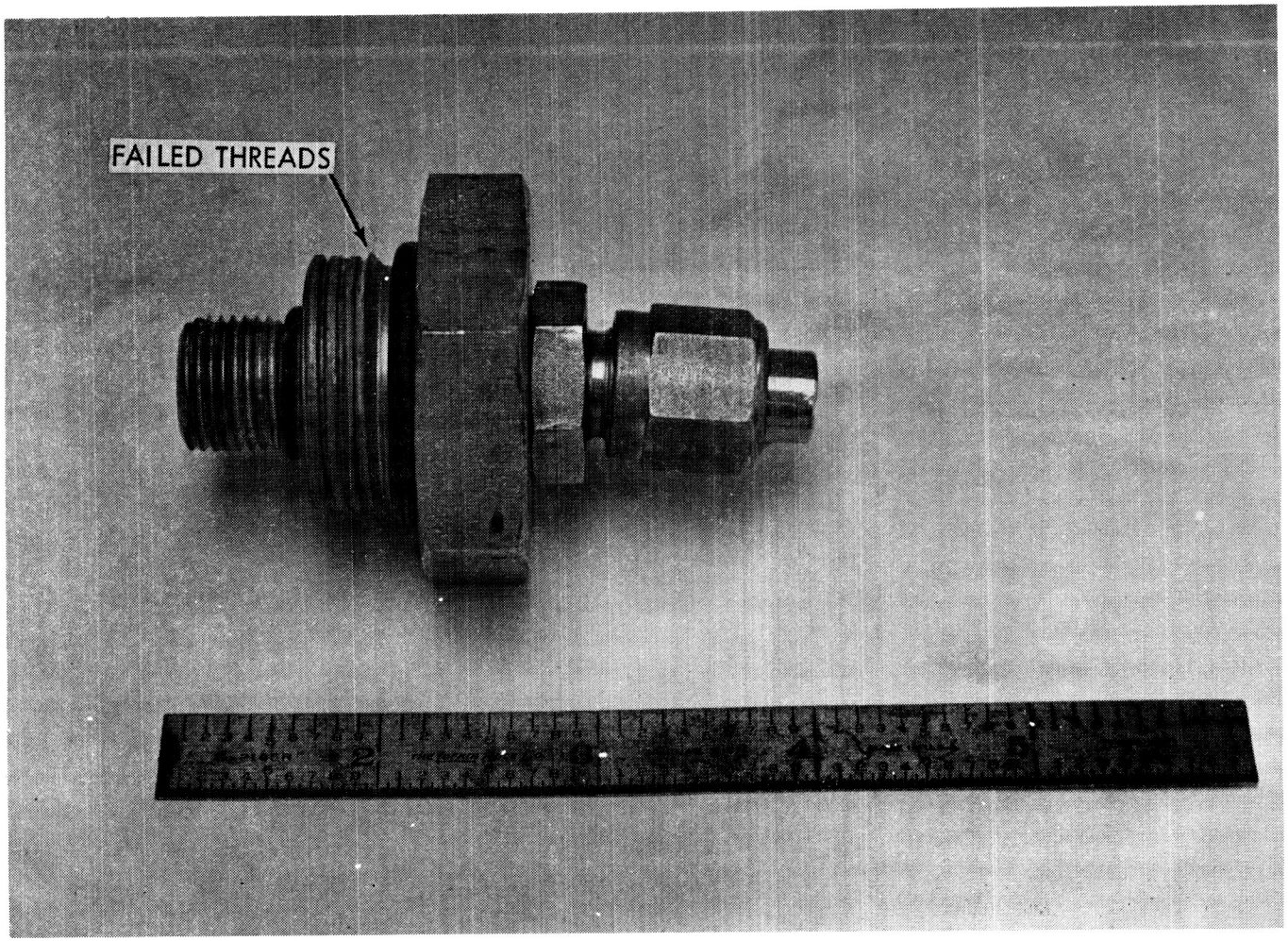


Figure 13-4. Thread Failure on Specimen 3

APPROVAL

TEST REPORT

FOR

PNEUMATIC FILTER, 3/8-INCH

Permanent Filter Corporation Part No. 10813

NASA Drawing No. 10437650

SUBMITTED BY:

Darrell W. Miller for

C. G. Schibler
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APPROVALS

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Program Supervisor

V. J. Venko

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Engineering Department

TEST REPORT

FOR

PNEUMATIC FILTER, 3/8-INCH

Permanent Filter Corporation Part Number 10813

NASA Drawing Number 10437650

ABSTRACT

This report presents the results of tests performed on three samples of the pneumatic filter 10437650. The following tests were performed:

1. Receiving Inspection
2. Proof Pressure
3. Bubble Point
4. Low Temperature
5. High Temperature
6. Flow
7. Surge
8. Vibration
9. Salt Fog
10. Dirt Holding and Collapse Pressure
11. Final Inspection
12. Burst

Collectively, the performance of the specimens was in accordance with the specification requirements of NASA drawing 10437650 throughout the test program.

It was noted, however, that the specification allows 2-psi differential pressure for 10 cfm at 6000-psig inlet pressure and the actual differential pressure for 3500 scfm at 6000-psig inlet pressure was 470 psi. The test results were confirmed by parallel testing a similar permanent filter.

The cases of two filters failed structurally at 24,000 psig.

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